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EDITORIAL

Fungicides for Mouldy Rot Disease

The article by Mr. Beeley in this journal is published as a record of the investigations which have been carried out during the last few years, with the object of establishing an official approved list of fungicides for the treatment of Mouldy Rot disease of the rubber tree caused by the fungus—*Ceratostomella fimbriata.*

A brief history is given of the previous investigations carried out on the treatment of the disease in Malaya, and the steps which led up to the scheme which has been approved and adopted by the Government of the Federated Malay States.

A description is also given of the laboratory technique and field tests which are carried out on all proprietary fungicides submitted for examination under the scheme. It is shown that, owing to the nature of the disease and the delicate character of the exposed tissues of the trees which are attacked, the treatment of the disease with fungicides offers a special problem in plant pathology, since the margin of safety in the control or destruction of the fungus, and damage caused by the application of a fungicide to the tissues of the tapped panel on the rubber tree, is small.

On this account many proprietary fungicides which are suitable for the control or destruction of the fungus are unsuitable in practice on account of the damage caused to the inner bark or cortex and cambium of the tree.

The investigations also indicate that, while the laboratory tests used are valuable as a preliminary guide, the criterion of the value of any particular fungicide is a field test.

The scheme has been working successfully for several years and, as will be seen, only a comparatively small proportion of some forty proprietary fungicides previously tested have secured a place on the approved list of fungicides suitable for the treatment of the disease. "Standardization" on the lines adopted for

other products used as insecticides and fungicides is not possible since laboratory tests and any chemical examination of the products are only of value as a preliminary guide.

Oidium Heveae Leaf-Fall in 1936.

A survey of the extent of leaf-fall caused by the mildew fungus—*Oidium Heveae*, during the refoliation period after "wintering" in 1936, has been made and the results are published in an article by Mr. Beeley in this journal.

Owing to the heavy rainfall in most parts of Malaya during January and the subsequent hot dry period in February "wintering" was severe and rapid. In many districts about 90 per cent of the rubber trees shed their foliage simultaneously and refoliation was also rapid. As a result, although leaf-fall due to Oidium was reported from a large number of estates, the attacks were very mild and occurred generally on only about the 10 per cent of late wintering trees which refoliated when the dull showery and somewhat cooler weather was favourable to the development of the fungus.

Refoliation generally in 1936 has been excellent and the new leaf is of a good, dark green, healthy colour. The larger number of cases reported, compared with 1935, is considered to be due to the ease with which the disease could be detected on trees which were attacked, on account of the contrast of colour on surrounding healthy trees.

As a result of the mild attack of the disease, very little sulphur-dusting was carried out and no records are therefore likely to be available this year indicating any improvements due to treatment.

In a number of cases leaf-fall was shown to be due to insects—Thrips, spider and mites.

In a few cases, leaf-fall due to windstorms also occurred. This is considered to be due to the heavy foliage.

These annual records of secondary leaf-fall are of considerable value in relation to the influence of climatic and other conditions on the incidence and virulence of the disease.

The response of managers of estates to the circular issued by the Institute early each year requesting them to report abnormal leaf-fall and, if necessary, to send specimens for diagnosis has been gratifying.

The reports of the Asiatic Rubber Instructors of the Small-Holders' Rubber Advisory Service, in respect of secondary leaf-fall on small holdings are also of value.

The number of reports of such leaf-fall on small holdings during the refoliation period of 1936 has been very small.

The evidence confirms the opinions previously expressed by the Institute on the relationship between outbreaks of this disease and the climatic conditions during refoliation.

It is of interest to note that Mr. Beeley was able this year to carry out a rapid preliminary aerial survey, a method which in future may assume increasing importance.

Soils in relation to Rubber Cultivation

The article entitled "Notes on Tropical Soils with Special Reference to Malayan Soils for Rubber Cultivation" by Mr. Hamilton, is compiled from a lecture given by him before the Nilai-Labu Branch of the Incorporated Society of Planters, Malaya. This lecture has also been repeated recently by special request before the Seremban-Rantau-Port Dickson Branch of the Society.

These notes and the conclusions drawn from investigations in progress in the Soils Division of the Institute should prove of interest and value to all rubber planters since they confirm observations already made, but not previously proved by actual investigations of profiles, on the problem of the general fertility of Malayan soils and also illustrate the comparatively rapid deterioration which occurs in such soils if satisfactory agricultural methods are not adopted.

The investigation of the profiles of a number of soils under virgin forest, and the comparison of the results with those of similar types of soils on adjacent areas under cultivation with rubber or other products for some years, are of considerable interest and value.

The limited experimental planting on reserve areas permitted under the International Rubber Regulation Scheme, which will be carried out in Malaya under the control of the Institute, will enable much valuable information to be acquired in connection with soil problems as well as in many other directions.

The problem of the humus content of Malayan soils, and the necessity of combining the application of fertilisers with the development of natural or other cover plants on replanted areas, is also referred to and the fact that such methods for the improvement of soils are complementary, as has previously been emphasized by us, are confirmed by the observations made in this article.

An investigation of the soil profile, in accordance with the methods proposed by Hardy in the West Indies is of particular value in relation to the cultivation of a "permanent" crop such as the rubber tree.

The Constituents of Hevea Latex

The investigation of the composition of Hevea latex is a fundamental problem which is of the greatest importance in relation to the physiology of latex production and to the quality and properties of latex and raw rubber.

A certain amount of preliminary investigation has been carried out previously chiefly in connection with the isolation of constituents which function as accelerators of vulcanisation and as anti-oxidants.

The extending use of latex and the changes which may occur in latex due to the ammonia used for preservation also enhance the value of more complete information of its composition.

It is also very desirable to investigate the constituents of latex in the country of origin at the earliest possible time after the latex is obtained from the tree in order to be certain that changes due to fermentation or caused by chemical and physical treatments have not occurred. If these constituents are identified in fresh latex, it is possible to indicate or to determine the changes which such constituents may undergo under specific treatment. It is well-known for example that ammoniated latex after storage has different properties to fresh latex or latex which has only been recently ammoniated.

It is probable also that latex from different clones may vary and that such variation is due to changes in the amounts of certain non-caoutchouc constituents. Previous investigations carried out in the Institute have also indicated seasonal differences.

Before such differences can be determined, it is essential to ascertain as closely as possible the nature of the various constituents present in normal bulked latex from a mixed population of seedling material.

For a study also of the problem of the physiology of latex production, a knowledge of the complete composition of latex is also essential.

On account of the attention which has had to be given during the last few years to specific problems of "immediate importance" it has not been possible until recently to give the continued and concentrated attention which is essential in conducting fundamental work of this nature.

The preliminary study of this problem published by Dr. Roberts in this Journal indicates the presence of several constituents in latex, one in considerable quantity, which will undoubtedly prove to be of considerable importance in relation to the quality and properties of latex and rubber, and which will prove valuable as a basis for further work in relation to the physiology of latex production.

Latex Straining Materials

In the Institute Journal, Vol. 6 No. 2, 1935, attention was drawn to the possible danger of using brass wire gauze sieves for the straining of latex on estates.

It was emphasized that in no case should brass wire gauze sieves be used for straining preserved (ammoniated) latex.

The present journal contains an article entitled "Latex Straining Materials" by Messrs. Hastings and Sekar which gives the results of investigations carried out to determine to what extent contamination of latex and raw rubber with copper is likely to occur in practice when the latex is passed through brass wire sieves in the estate factory.

The technique of the method used for the determination of minute quantities of copper is also described for the benefit of other investigators. It is shown that minute quantities of copper, which are too small to cause tackiness in raw rubber even after some months' storage, reduce the plasticity and seriously affect the ageing properties of the rubber.

In the case of latex used for dipped goods or impregnation contamination may be more serious, since all the copper contained in the original latex, will remain in the finished article, whereas when latex is coagulated and converted into sheet or crepe rubber, a portion of any copper present in the latex is removed in the serum and the water used for washing the coagulum. Experiments with other straining materials show that monel metal, nickel or stainless steel gauze may be substituted for brass for straining ordinary latex which is to be converted into sheet or crepe. Stainless steel or nickel gauze should be used for straining field latex which is to be ammoniated while it is desirable to use either stainless steel or voile gauze for straining latex which has been ammoniated for shipment.

Although these alternative materials are more expensive than brass wire gauze, they all have the merit of longer life during service.

Coagulants used by Small Holders

The Institute Journal (Vol. 4, No. 2 and Vol. 5, No. 3) contains articles on the use of sulphuric acid as a coagulant for latex. It has since appeared desirable to carry out a systematic investigation of coagulants used generally on rubber small-holdings in view of the opinions expressed by rubber manufacturers, on the possible harmful effects on rubber goods prepared from raw rubber coagulated by the use of this acid since it was known that sulphuric acid and alum were in use on some rubber small-holdings at the time the former articles were written.

As a result of the formation of the Small-Holders Rubber Advisory Service of the Institute and the appointment of a number of Asiatic Rubber Instructors throughout the country it has been possible to carry out this systematic survey. The coagulants used on small-holdings for the coagulation of latex were collected by the Instructors from sellers in a large number of districts. The article by Dr. Rhodes indicates the extent of the use and distribution of sulphuric acid alone or in mixtures and also of formic and acetic acids for this purpose.

The investigations show that sulphuric acid is used to a much wider extent than has been supposed and that it may possibly have been the cause of difficulties experienced during the vulcanization and manufacture of rubber goods.

The advice given and the propaganda carried out by the Rubber Instructors are likely to have a useful effect in reducing the use of sulphuric acid and indicate one among several other valuable services already rendered by the Small-Holders Advisory Service since its inauguration in the middle of 1934. It can be stated that considerable improvement has already been effected in the preparation of sheet rubber on small holdings as a result of the efforts of the Instructors.

Seedling Trees derived from proved Clones

The Note by Mr. Mann in this Journal on "The Study of Seedling Trees derived from proved Clones" constitutes the first results in respect of yields obtained from seedlings obtained by the hand pollination of various Pilmoor Estate clones, grown at the Institute Experiment Station.

In view of the temporary cessation of work on seed selection as a result of retrenchment in 1932, when it was considered by those in authority that such work should be discontinued, it is fortunate that some material had already been established by the Institute for a study of this important method of improvement of planting material. The results indicate that one and probably two of the clones investigated will be of special value as parents in the production of planting material of high-yielding value.

There is a strong tendency at the present time to plant clonal seed in preference to budding. This is due partly to the fact that there is still a body of opinion which is not convinced of the ultimate value of budded material and partly to the desire for a procedure viz. the planting of seeds, which is simpler to carry out than the budding operation.

Attention has previously been called to the lower yield of illegitimate seedlings derived from clonal plants where one of the

parents is unknown and also to the considerable variation in yield of individual seedling trees as compared with budded plants.

It is perhaps again necessary to draw attention to the risks incurred, in respect of yields, if clonal seed is planted. Much further study, which must be continuously carried on, is essential before recommendations can be made for the planting of clonal seed in preference to budding.

Planting Holes and Mosquito Breeding

The attention of estate managers is specially invited to the article and separate leaflet issued with this journal on the danger which may arise from the breeding of mosquito larvae in planting holes containing rain water, when these are dug and left unfilled for some time.

OFFICIAL GRADING OF PROPRIETARY FUNGICIDES FOR TREATMENT OF MOULDY ROT DISEASE OF RUBBER TREES

BY

F. Beeley

The primary object of this article is to place on record a history of the treatment of Mouldy Rot disease of the rubber tree particularly in relation to the establishment of an official approved list of proprietary fungicides which have been investigated and proved to be effective for the treatment of the disease.

The discovery of this disease of the tapping panel of rubber trees in 1916 presented to plant pathologists a special problem in that the tissues affected by the disease are as delicate, if not more so, than the fungus which causes the disease.

It was early discovered that the delicate cambial tissues exposed by the tapping process were particularly sensitive to the contact of minerals or liquid sprays containing dissolved mineral salts. The use of organic compounds, represented by such proprietary tar-acid mixtures as Jodelite, Dougalite, Solignum, Noxo, Brunolinum and Coal tar, normally used for the preservation of structural timber, was investigated and it was found that, when applied neat, they caused considerable damage to the tapped surface of the tree so that weaker mixtures made by emulsifying these products in water with soap became the vogue. Proprietary preparations of emulsified tar oils under various names were soon available on the Malayan market.

The Rubber Growers' Association (Third Malayan Report 1919) issued a report upon tests of a number of fungicides carried out by Sanderson and Sutcliffe. In this report it is pointed out that the strength of fungicide required to kill the Mouldy Rot and Black Stripe fungi in laboratory tests bears no relation to the strength of the same fungicide required for use in the field.

In this report a list of thirteen desirable points in relation to fungicides is given as follows:—

1. Its use should be possible in strength sufficient to kill or prevent the development of the particular organism against which it is used.

2. The planter should be able to tell by a glance that the substance has been applied.

3. It should not have a deleterious effect on the finished rubber.

4. It should not burn the tissue.

5. The penetrative power should be sufficient to be effective but not sufficient to cause wounds. (The thickness of the bark when the application is made is an important factor here.)

6. The application should be simple and rapid, entailing a minimum of expense.

7. The planter should be able to rely on different samples being of constant composition or very nearly so; this applies more particularly to liquids which are used neat or undiluted and which penetrate deeply.

8. The preparation must be easy to handle.

9. Its use must be possible daily (applies especially to liquids used as daily wash) without injurious effect on bark or wood.

10. If used in considerable dilution it is better if miscible with water.

11. It should not coagulate latex.

12. The initial cost must be reasonably low.

13. Re (12) if the initial cost is high this may be counterbalanced if the preparation can be used with effect in more dilute mixture than a cheaper preparation.

Further work on the control of Mouldy Rot is found in the Bulletins of the Department of Agriculture, S.S. and F.M.S.

Sharples, Belgrave, Norris and Ellis (Bulletin 31, 1920) suggest the use of an emulsified form of Brunolinum known as Brunolinum plantarium, while South and Sharples (Bulletin 37 1925) point out the danger of bark damage from use of Jodelite or too strong mixtures of Brunolinum and tar or water-oil emulsions. They also state that "laboratory tests carried out by testing cultures against percentage strength of disinfectants are useless and misleading when used as a basis for field tests". An account is also given of elaborate field tests carried out by the proprietors of the preparation "Agrisol" under the supervision of officers of the Department of Agriculture as a result of which the use of a 20 per cent mixture of Agrisol in water was widely adopted for control of Mouldy Rot in Malaya. It was on the basis of these tests that Sharples, on assuming his appointment as Head of the Pathological Division of the Rubber Research Institute in 1931, formulated a scheme for the testing of proprietary fungicides for use in control of Mouldy Rot with a view to providing a list of preparations which can be used with safety and give a high degree of efficacy.

Owing to the generally unsatisfactory position, particularly in regard to the supply of suitable fungicides to rubber small-holders

a meeting of the Heads of the Pathological Divisions of the Department of Agriculture and the Rubber Research Institute was arranged to discuss the standardization of fungicides for treatment of diseases of the rubber tree. As a result it was agreed that standardization was not sufficient in itself and that controlled field tests were essential. The problem was also referred to the Director of the Imperial Mycological Institute, London, who expressed his agreement with these views; he also mentioned that in Germany there was a scheme operating in different localities for field testing of fungicides which if found satisfactory were included in a list of approved fungicides.

After further discussion at an Inter-Departmental Conference of the Department of Agriculture, the Co-operative Societies Department and the Rubber Research Institute, it was agreed that considerable preliminary investigation was necessary before any recommendations could be made.

A list of the proprietary fungicides available in Malaya for the control of rubber tree diseases was drawn up, and a scheme proposed for the investigation of these in the Rubber Research Institute.

This scheme after approval by the Board of the Institute was submitted by the Director of Agriculture to the Government of the Federated Malay States and approved. As a result, the following Notice was published in the F.M.S. Government Gazette, Vol. 23 No. 7 of the 27th March, 1931, page 713.

NOTICE.

The attention of the Department of Agriculture has been directed to the necessity which exists for the standardization of disinfectants which are approved for use in the treatment of Mouldy Rot on rubber plantations.

2. From the date of this notice therefore in all notices served by the Department of Agriculture under the Plant Disease Prevention Ordinance for the treatment of Mouldy Rot only preparations will be specified which have been subjected to test by an approved authority and proved to be effective.

3. At present the list of such preparations includes:—

1. Agrisol
2. Izal—in certain cases.

4. The Department will be prepared to extend the list to include any other preparations which have similarly been proved to be effective, by approved authorities. It should be pointed out that certain other preparations in common use on estates have also been reported to give satisfactory results but, as these have not yet been subjected to systematic tests, they are not at present included in the list.

5. The approved authority for carrying out such tests for Malaya will be the Rubber Research Institute and the carrying out of such tests will in future be undertaken by the Rubber Research Institute; applications from proprietors of fungicides for the performance of such tests with a view to their inclusion in the list should be addressed to the Director of the Rubber Research Institute accordingly.

6. The tests will be made strictly in accordance with priority of receipt and also in accordance with the capacity of the Institute to deal with them when received.

7. All supplies of disinfectants required for such tests must be furnished without charge by the firms applying for such tests while the actual expenses involved in carrying out the tests must also be borne by the said firms.

8. For further information regarding tests application should be made to the Rubber Research Institute.

9. Proprietors of fungicides and their representatives in Malaya are further notified that preparations which, on samples supplied, have passed the tests prescribed by the Rubber Research Institute will only be admitted to the list provided that the proprietors are willing and able to give a guarantee that the formula for the composition of their preparations will remain unchanged.

10. Should any proprietor of an approved fungicides desire to make any change in the composition of the fungicide he must notify the Director of Agriculture and submit samples of the preparation in its new form for further tests if required to do so. Failure to do this may entail the removal of an approved preparation from the list.

When applications are received from the proprietors of fungicides for the testing of a particular product, the conditions in the above notice are stated in a letter sent to the applicant. In addition, the applicant is informed that the field tests can be carried out only when suitable diseased areas can be found during the rainy seasons, so that no guarantee can be given as to when the results of such tests will be available. The maximum cost of carrying out the tests is $200/- (Straits) which the applicant is requested to deposit with the Institute before the tests are undertaken.

The applicant is also informed that the Institute reserves the right to publish the results, although the usual procedure is only to publish the name of the product, if satisfactory, in the list of fungicides approved for the treatment of the disease.

Since the adoption of this scheme the Institute has tested over forty fungicidal preparations of which only a small proportion have successfully passed the tests and been approved for a place on the White List which at the present date is as follows:—

	Name.	Date gazetted F.M.S.	Concentration to be used.
1.	Agrisol ...	27. 3.31	15 to 25 per cent. in water
2.	Izal ...	27. 3.31	3 to 5 per cent. in water
3.	Black Cyllin ...	7. 6.32	5 to 10 per cent. in water
4.	Killgerm ...	17. 6.32	5 to 10 per cent. in water
5.	Kilsol Red ...	17. 6.32	5 to 10 per cent. in water
6.	Brunolinum Plantarium	17. 6.32	10 to 15 per cent. in water
7.	Agrisol White ...	6.10.33	10 to 15 per cent. in water
8.	Cargillineum 'B' ...	28. 7.33	To be used neat
9.	Durycolium ...	6. 3.36	To be used neat

It is also of interest to record that a session of the Third Imperial Mycological Conference held in London in 1934 was devoted to a discussion on the "Methods of Standardization of Insecticides and Fungicides". An account of the opening speech quoted from the official report of the Conference reads as follows:--

"Dr. Gussow (Canada) in introducing the subject gave an outline of the "procedure adopted in Canada, the United States and Germany. In Canada "an Act for the regulation of the sale of fungicides was passed in 1927, the "primary object of which was to prevent the sale of fraudulent products. All "products have to be registered, the well-known and tested substances are "granted registration immediately; those tested to a limited extent but known "to be effective are allowed registration temporarily; for those untested, ex- "perimental data are requested and tests arranged, whilst the worthless materials "are refused. Applications for registration require to be accompanied by a "fee of $20 gold, and the name and percentage of all ingredients have to be "stated. Every registration expires on 31st December. In the United States "similar control is established. In Germany the procedure involves duplicated "tests the data from which are referred to an official body, which rejects or "permits the use of the material. The ingredients are either disclosed or com- "municated confidentially. The testing of fungicides by field tests gives the most "satisfactory results, but it requires money and time, and it is very desirable "that research should be undertaken in connection with the laboratory testing "of such materials."

Mr. Sharples, who represented the Rubber Research Institute, gave an account of the testing of fungicides in Malaya which was greatly appreciated by other delegates.

Below, an account is given of the laboratory work which led to the present method of field testing of fungicides.

PART II

Proposed Tests for Fungicides

MICROSCOPICAL

If in emulsion, globule size is of importance and it is found that the smaller the size of globule the greater the fungicidal effects, the more permanent the emulsion and the greater the ease of mixing with water. Large globules tend to coalesce easily to give an oily film detrimental to living plant tissues.

If in oil or paste form the physical properties are noted for ease of use and covering power.

If in powder form, fineness and free-running non-aggregating properties are noted.

Globule size for an emulsion is usually 1—2 μ and not greater than 3 μ—*i.e.* globules in continuous Brownian movement when in a water film. Fine powders should have the following particle sizes—Min 3—6μ; Bulk 12—18μ; Max 30 μ. Larger particles, like

grit, are considered unsatisfactory though a few large particles often assist in preventing aggregates and in maintaining free-running powder form, as all fine powders tend to aggregate on standing in bulk.

Chemical

The product is examined to determine the nature of the fungicide and its concentration from which the approximate strength for use in the field can be determined *e.g.* a fluid which on treatment with 20 per cent sulphuric acid shows a content of 40 to 50 per cent of tar acids will probably be successful in the field at a concentration of 7 to 15 per cent in water. If 90 per cent of tar acid is found then a strength of about 3 to 5 per cent will be necessary in the field.

Only one paste fungicide the composition of which was supplied by the makers has been tested by us.

If the product is too alkaline or acid it is likely to be detrimental to plant tissues.

Penetration Tests on living Bark

The bark of a rubber tree is excised to imitate light, medium and deep tapping over an area of at least 6 x 2 ins. and the fungicide is applied at various predetermined strengths to effect (a) slight penetration of the bark (b) medium and (c) deep or harmful penetration and killing of the bark. The lethal strength is noted. Two to four days are usually sufficient to determine this factor.

Any damage done to the bark by volatile components or invisible fluids is often difficult to detect, but a good test is to make a knife-edge cut into the remaining bark across the excised surface and to note the condition of the latex or juice which exudes. A thin, almost colourless fluid indicates danger and it is often found that the cambium beneath is discoloured—being more sensitive than the bark (cortex) to the gas or fluid –and slowly dies. A thin, milky fluid shows that the maximum concentration has been reached, while a thick, creamy latex indicates a healthy condition of the bark.

Surface effects on the bark are noted, since a fluid which kills, shrivels and blackens the outer cells is hardly desirable whereas some fungicides appear to improve the condition of the outer cells and to promote bark renewal.

It should be noted that cells near the cambium are far more sensitive to fungicides than cells further out in the cortex. Therefore the test of a fungicide to be applied to the panel after tapping is that it should only penetrate lightly on excisions made close to the cambial region.

On the outer hard bark most of the fungicides may be used at higher concentrations without danger to the inner bark.

The visual penetration four days after application of the fungicide should be not greater than one millimetre, preferably less than half a millimetre.

The tests are carried out under reasonable shade as direct sunlight on the exposed tissue may cause considerable damage which may be erroneously attributed to the fungicide. Dark mixtures particularly appear to penetrate more deeply into bark in sunlight than they do under shade, owing to the heat absorbing properties of the black surface.

The use of mixtures of fungicidal coal-tar oils, in an asphalt-kerosene medium, on the tapping panel has been abandoned on account of the great absorption of heat on the black surface particularly during wintering, which follows so quickly on the rainy Mouldy Rot season.

Laboratory Tests

Much useful work has been done by various research institutions throughout the world to find a satisfactory laboratory means of determining the fungicidal, bactericidal or germicidal value of a preparation. None of these have yet been considered very satisfactory. Though the Rideal-Walker test has found considerable popularity as a means of determining bactericidal value it does not follow that the product tested will give the same efficacy when used upon living plant or animal material. Recently a compound of high "R.W." coefficient proved useless as a fungicide on rubber trees whereas one of comparatively low "R.W." coefficient proved very efficient in control of Mouldy Rot.

It has been found that, with cultures of the Mouldy Rot fungus, *Ceratostomella fimbriata*, in agar medium, the strength of say a tar-acid emulsion required to kill the fungus was so low compared with that required in the field, that no indication could be obtained from such culture tests which would enable the value of a specific compound, for the purpose of control of Mouldy Rot or indeed any other disease of the tapping panel, to be judged. It could be considered as giving merely a comparison of the lethal efficiency of the various compounds in that medium.

An alternative laboratory method was also investigated. This consists of inoculating clean strips of living bark 6 × ¼ in. in sterile tubes with the Mouldy Rot fungus. The fungus is allowed to develop on the cambial side of the bark strip for seven days, after which the thick-walled resting spores are found to be present in great numbers. The strips of bark are then immersed in beakers containing various strengths of the fungicide under test. Scrapings

of the fungus and tissue are then taken from the strips of bark at short intervals of time, usually after immersion for 2, 5, 10, 15, 20, 25 and 30 minutes, and the scrapings are washed and inoculated into a tube or plate of nutrient agar.

This time-immersion method of test gives results considerably more comparable to the field tests than the Rideal-Walker test, but is still so inferior to the field-test method that it has been decided that the latter should be considered the only suitable final test of the efficacy of a fungicide for the control of the disease.

Field Tests

In carrying out field tests the following practice is adopted.

Choice of Site

An area of rubber carrying a heavy infection of Mouldy Rot is selected at the most convenient distance from the laboratories.

Lay-out of Plots

Trees showing mouldy tapping panels are numbered by stencil and divided into plots of 25 trees, each having 100 per cent infection. The condition of neighbouring fields of trees serve as controls to indicate the normal progress of the disease when no treatment is given.

In the case of a tar-acid emulsion the preliminary laboratory tests will have given some indication of the probable strength of the fungicide required for the field tests—say 10 per cent. Four plots of 25 trees are then treated with a different concentration around this figure say 5, 10 and 15 per cent in water. Treatment by spraying each tapping day is given and a close watch is kept for the appearance of symptoms of bark burning or too deep penetration of the fluid, together with a daily record of the number of trees showing mould. Within two weeks it can usually be discovered that the lowest strength is useless for killing the fungus while possibly the highest strength, though killing the fungus within the first few days, also shows signs of over-penetration and consequent bark burning. Thus the early field tests give the probable minimum strength required to kill the fungus and the maximum safe strength at which the fungicide can be applied to the bark without injury.

The plot receiving only a 5 per cent strength of fungicide will then be treated with a 7.5 per cent solution and the "15 per cent" plot with a 12.5 per cent solution, while a further main plot of 100 trees will be treated as in estate practice with an average

strength of fungicide, say in this case a 10 per cent concentration, for one month, records being taken each day of the number of trees mouldy and conditions of the renewing bark before, during and after experiment.

During these tests no special effort is made to prevent infection from neighbouring untreated trees, and each tapper may tap a number of treated and untreated trees at will so that the test is as thorough as possible.

When treatment is stopped, a note is usually made of the time required for the reappearance of mould on the treated trees.

Any preparation which fails to control the disease during a period of one month's treatment is considered as unsuitable for a place on the White List of fungicides for control of the disease.

On the other hand, fungicides which cause bark burning at or near the strength required for killing the mould are also regarded as unsuitable. In fact this has been the chief reason for rejection of many proprietary products.

As a point of interest a record, published in the Annual Report of the Rubber Research Institute 1934, p. 94 of an experiment to demonstrate the efficiency of the various types of fungicides used for the control of the disease in heavily infected small-holdings rubber areas is given below. The materials used were Killgerm (a proprietary fungicide) and "Linsocresyl" (prepared in the Pathological Division), as representatives of the tar-acid emulsions; Cargilineum 'B' mixture and Agrisol Paste (both proprietary fungicides), as representatives of the greasy waterproof pastes; Singapore Tar and Asphalt-Solar Oil plus 10 per cent Brunolinum, as representatives of the black water-proof paints which find a fairly wide use. A resin-spirit mixture in common use in Netherlands India is also included but, during the wet weather, was found seriously to damage the bark, although on the advent of dry weather early in December further applications proved to have no ill-effects on the renewed bark. The results are given in tabular and graphical form below. The initial degree of infection in each plot was 100 per cent. The condition of the renewed bark was noted weekly and the flow of latex was judged by pricking the renewing bark with a knife point. It has frequently been noticed that, if the fungicide has damaged the bark, even only slightly, the latex flow is poor and the latex produced is of a thin watery nature. The results indicate the superiority of the tar acid emulsions.

Guarantee

A proprietor whose preparation gives satisfactory results in the above tests is required to give a guarantee that the composition

Fungicide Tests in Control of Mouldy Rot

	Fungicide	Application	When clear of disease	Condition of bark	Latex
1.	Killgerm 10 per cent in water	Daily	After 16 paintings	Very good condition	Good
2.	Linsocresyl 10 per cent in water	Daily	After 17 paintings	Good condition	Good
3.	Cargilineum applied neat	Every 4th day	After 6 paintings	Fair to good	Good
4.	Resin Spirit applied neat	Every 3rd day	After 6 paintings	Hard crust formed. Bark damaged in wet weather. Renewal of bark good in dry weather.	Fair to Good
5.	Singapore Tar applied neat	Every 4th day	After 7 paintings	Burning where the bark is tapped deeply; otherwise good bark renewal.	Fair
6.	Asphalt-Solar Oil applied neat	Every 3rd day	After 7 paintings	-do-	Fair
7.	Agrisol Paste applied neat	Every 4th day	After 6 paintings	-do-	Fair

and formula of the preparation will remain constant and, should any alteration take place, he is required to notify the Director of Agriculture at once, so that, if necessary, further tests can be made. If these conditions are complied with the preparation is gazetted by Government and placed on the official list of fungicides recommended for use in control of the disease.

Nomenclature

In conclusion a few words on the terminology used in this article may serve to clear up misunderstandings. In Webster's International Dictionary the following meanings of the words Fungicide, Antiseptic and Disinfectant may be found.

"Fungicide (n)—Any substance which destroys fungi"

"Antiseptic (n)—An antiseptic substance. That which may be used to destroy bacteria with little or no harmful effect on the living body."

"Disinfectant (n)—A substance adopted for destroying the bacteria in, and rendering harmless and inoffensive, objects, places

FUNGICIDE TESTS - SETAPAK.
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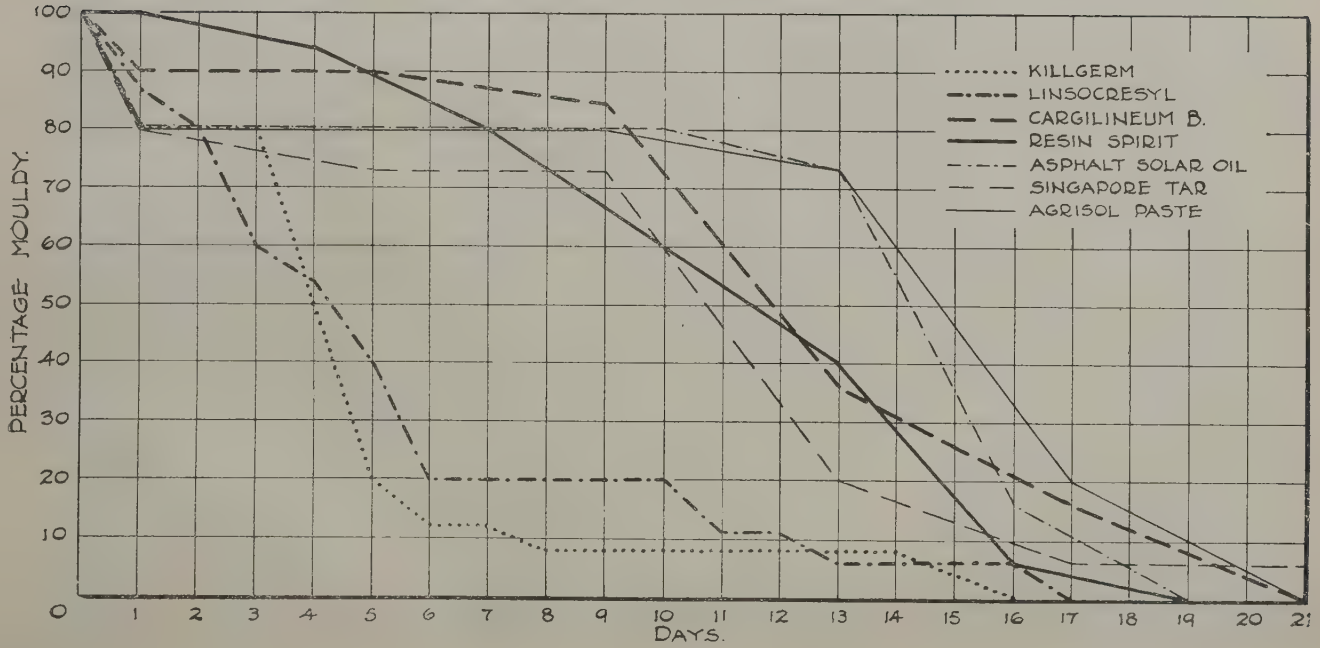


or materials containing putrefactive or pathogenic bacteria. A disinfectant differs from an antiseptic in not being intended for use upon the living body; hence many substances not applicable as antiseptics may serve as disinfectants or stronger solutions of antiseptic substances may be employed."

If, in the above meanings, the word "rubber tree" is regarded as the living body, the correct use of the above terms in plant therapeutics can better be understood.

A fungicide is a substance which will destroy fungi without injury to plants upon which the fungi are growing.

A disinfectant is a substance which will destroy fungi and bacteria irrespective of its action upon living plants. As a rule disinfectants are of concentrated form and would almost certainly be fatal to the plant.

In general a substance used in low concentrations may be used as a fungicide while the same substance in higher concentration becomes a disinfectant and plant destroyer. The margin between these two strengths may be regarded as the margin of safety and the greater this margin the more safe the material for use as a fungicide. This is of importance when it is remembered that in wet weather it is more difficult to control Mouldy Rot and there is a great tendency to use stronger fungicides; if there is only a small safety margin this is impossible without having considerable trouble from bark burning.

In the White List of fungicides given previously the normal strength for use of the fluid, and the maximum strength which it is reasonably safe to use under abnormal conditions, *i.e.* during wet weather, are given.

Summary

A brief history is given showing the reasons which led to the official testing of substances used for the control of Mouldy Rot and the provision of an official list of fungicides for use for such purpose in Malaya.

A description is given of laboratory and field tests formulated for the purpose of testing these substances.

OIDIUM HEVEAE

Report on the 1936 Outbreak of Hevea Leaf Mildew

BY

F. Beeley

The weather experienced in Malaya during the early part of 1936 was unusual in that the month of January, which is usually a dry month showed heavy rainfalls at most meteorological stations throughout the country. This made many managers and agents anxious for, if the expected dry weather failed to materialise, then a heavy outbreak of leaf mildew would be almost certain to occur in the new crop of leaf. The effect of the wet weather in January was to delay wintering by at least four weeks, particularly in the central and northern parts of Malaya. The easterly winds, following the north-east monsoon, did not materialize until the second week of February when the hot dry weather began.

A full month of dry weather induced an even and almost complete wintering of rubber trees in all inland rubber areas; the coastal districts were a little later and the wintering less severe. Similarly, as stated in last year's report, local changes in weather conditions caused by the proximity of hills, as well as the sea, affected the time and severity of wintering and the incidence of leaf disease in such environs.

The generally dry conditions continued until about March 10th, when a distinct break in the weather occurred and showery weather became more or less general throughout the country. By this time a heavy wintering of the trees had occurred and estates presented at one time a bare leafless mien associated more with temperate than tropical countries. Also from 50 to 70 per cent of trees had obtained a new canopy of foliage entirely free from leaf-mildew.

From March 10th onwards as a consequence of the dull showery weather the disease began to make its appearance but, in the great majority of reports received, the disease was described as being very mild and as occurring only in the few late wintering trees.

In general it can be said that the foliage and seed set in the old rubber was even better than last year and that the incidence of *Oidium Heveae* in the new leaf was practically nil up to the 10th March, and thereafter was mild and occurred only in the late-wintering trees.

The total number of estates however reporting outbreaks of *Oidium Heveae* this season was 161 or more than double the total number of reports for the 1935 season. This was almost certainly due to the contrast between the very good, healthy, deep green foliage produced before the weather became favourable for fungal attack and that produced during and subsequent to the attack,—the diseased leaves being more easily detected.

In younger rubber trees, Spiders, Mites, Thrips sp. and the Birds' Eye Spot fungus *Helminthosporium Heveae* caused considerable damage especially in trees from 5 to 8 years old; no fewer than 54 estates sent in specimens which were diagnosed as foliage attacked by Spiders and *Helminthosporium Heveae* or by Mites or *Thrips sp.*

Reference to Table I and the graph below will show the time of first-noticed mildew attack in the various States. The number of reports received during the season, when compared with last year, indicates the four weeks' delay in the present year's outbreak.

TABLE I

Oidium Heveae 1936

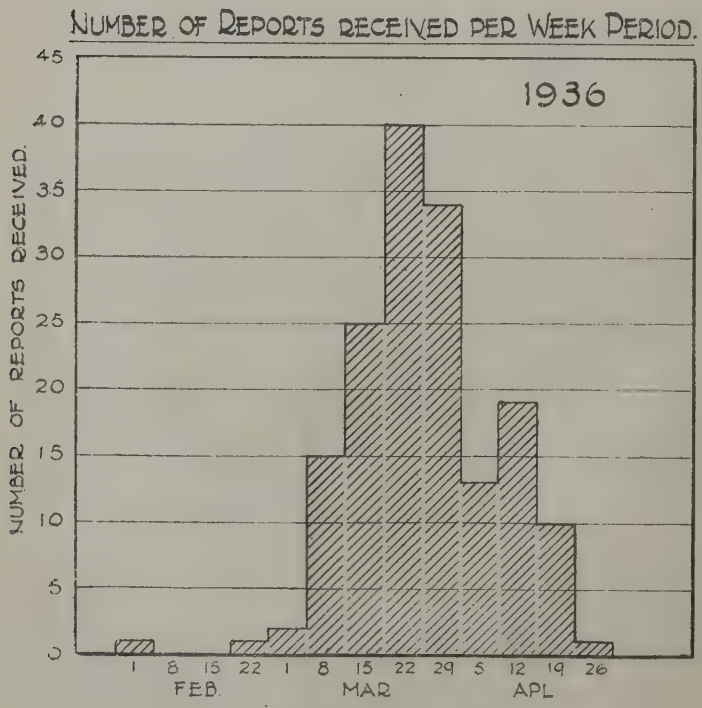
Reports received per Week from each State

	February				March				April					
	7 — 1	14 — 8	21 — 15	28 — 22	7 — 1	14 — 8	21 — 15	28 — 22	29—Apr. 4	11 — 5	18 — 12	25 — 19	2 — 26–May	Total
Johore ...						1	4	12	8	1		2		28
Malacca ...							4	4	7	1	2			18
N. Sembilan.				1	2	10	12	11	10	4	2	1		53
Selangor ...				1		2	2	6	2	2	10	1		26
Perak ...						1	3	2	4	2	1	3	1	17
P. Wellesley.								4		2				6
Kedah ...						1			3	1	3	2		10
Pahang ...								1			1	1		3
Total ...	...	...	...	2	2	15	25	40	34	13	19	10	1	161

As a result of the increased weight of new foliage developed this year a considerable amount of unusual leaf fall was caused by

wind. Owing to the sticky nature of the young leaf surface and the lack of development of the wood cylinder in the young shoots, a violent movement to and fro of the branches in a wind storm causes the fracture of leaf stalks by branches rubbing together, and in consequence leaves or whorls of leaves and flowers fall to the ground. This form of damage can easily be diagnosed in fresh specimens, but not if the specimens are old and in a decaying condition.

On March 8th and 10th just before the advent of wet weather, the writer made an aerial survey of most of the rubber growing districts, in order to gain a rapid view of the severity of wintering and the extent of refoliation in the various districts, and about 14 days later a tour of inspection by car was made to the same districts, and full notes were made of the condition of the foliage and the extent and virulence of the leaf mildew disease at the time. These observations, together with reports from estate managers, form the basis of the district reports given below.



Johore

North and Central Johore experienced very even and severe wintering so that, previous to the growth of new leaf, practically every tree in a particular area was leafless. Occasional fields of later-wintering rubber could be seen in the valleys.

In most districts over 50 per cent of new foliage had developed before the change to showery weather, which was less marked than in the more northern States.

In South Johore the drought did not appear quite so intense but wintering was more severe than in previous years, and the new foliage can be considered heavier and of deeper colour than has been seen for some years. A mild attack of the leaves of late-wintering trees by *Oidium Heveae* was experienced throughout the State but no case of heavy leaf-fall was reported.

Leaf damage in young rubber by Spiders and the Birds' Eye Spot fungus *Helminthosporium Heveae* was also recorded from most districts in Johore.

Malacca

North Malacca experienced a severe drought in February which caused a very severe wintering and early refoliation of the trees. This was especially noticeable in the poorer soils of northern inland regions and on the hilltops between the rice flats.

In the central and southern territory wintering, though severe, was not so acute as in the north. Trees on hill tops refoliated early and escaped the disease but trees in the more fertile watered valleys, being somewhat later in refoliation, were attacked by the disease; a large portion of the leaves were in the immature young stage so that numerous cases of a mild attack were reported from the southern parts of Malacca.

On the whole the foliage is heavier, of a better colour and more even than has been seen in the past few years.

The increase in number of reports of the disease from this State may also be taken as due chiefly to the greater interest shown in this disease and the greater ease with which the managers of estates could detect the diseased leaves.

Negri Sembilan

Wintering and refoliation followed a course similar to that of last year but some three to four weeks later. Trees on the peat and coastal clay soils wintered rather later and less severely than on the inland soils and, though a very heavy canopy of foliage was finally obtained, both *Oidium Heveae* and *Hevea Thrips* were to be found on the young leaf of many lower branches.

On the higher laterite coastal hills north and south of Port Dickson the wintering was generally good but occasional fields of late-wintering trees were attacked, in some cases fairly heavily.

Considerable improvement was observed further inland from Tampin to Seremban, Labu and Nilai, where the foliage was particularly heavy and of a good colour, most of it having been produced before the advent of dull, showery weather.

Southern parts of the State were not so early in wintering and many estates reported a mild attack in the late-wintering trees. Similarly, in the Semenyih district, late-wintering trees were observed to be attacked in the lower branches only but to a far less extent than in previous years.

The foliage, generally, represents a great improvement on recent years.

Sulphur dusting, which has been carried out during the past few years in the Nilai-Labu districts, was restricted to the period of refoliation occurring after the arrival of dull weather and, since the foliage was so good in all fields, little if any benefit appeared to have been derived from the dusting.

The large number of reports of the disease from this State may be due to the greater interest taken in the outbreaks and the more obvious difference between diseased and healthy foliage.

Selangor

In the inland areas of Selangor an almost complete wintering of all rubber trees occurred at the same time, so that the bare leafless appearance of rubber estates surprised residents of many years' standing in the country. Refoliation was at first excellent and rapid, but after the arrival of dull, showery weather, a few of the later refoliating trees, in the fertile watered valleys, suffered a mild attack of *Oidium Heveae*. The poorer hill areas may now be observed to carry an excellent foliage. In the coastal districts wintering was not so severe and, owing to later refoliation, trees were observed to be suffering from a mild attack of Oidium and of Hevea Thrips confined mostly to lower, shaded branches.

Generally, the report for 1935 may be applied here with the final results that the foliage throughout the State shows even further improvement, particularly around the foot-hill areas between Kuala Lumpur and Tanjong Malim.

Perak

The improvement in foliage of foot-hill rubber noted above was also obvious in this State from Tanjong Malim throughout Slim, Sungkai, Bidor and the Kinta Valley to Ipoh. North of Ipoh to Kuala Kangsar wintering has been early enough to enable

about 90 per cent of the trees to obtain new mature leaves before the rain arrived in the middle of March. As a consequence very little disease was noticed among such a wealth of good healthy foliage, which is reflected in the fact that only seven reports of a mild attack were reported from this 150 mile stretch of foot-hill rubber.

The trees on the coastal peat and clay areas of Teluk Anson wintered somewhat later and less severely but even so it was severe for that district. Considering the late refoliation the trees were fortunate in escaping with a very mild attack of both *Oidium Heveae* and *Thrips sp.* The resultant foliage is well up to last year's standard. The Sitiawan district again showed a more severe wintering and corresponding better refoliation than in previous years and at the time of inspection showed only a mild attack of late refoliating trees. Considerable variation in the condition of the foliage was noticed this year, as was the case last year, in the north-western districts of Perak. The wintering appears to be affected by the topography of the land around Gunong Semanggol and Gunong Bubu and conditions similar to those re-reported last year were repeated this year. On the whole, however, the wintering was slightly more complete and the refoliation considerably better than in previous years. Here also a mild attack of a few of the late-wintering trees was observed.

Province Wellesley

Wintering and refoliation, no doubt delayed by the January rains, took place only a week or two earlier than in the southern States. However this was sufficient to ensure the development of a canopy of new, mature foliage before the drought ended in mid-March. By contrast, disease was observed in a very small percentage of lower branches of late wintering trees.

Kedah

In South Kedah conditions were similar to those of last year and little signs of leaf mildew were observed, though spiders, mites and the Birds' Eye Spot fungus *Helminthosporium Heveae* were active in nursery and immature rubber areas.

In Central Kedah the foliage is slightly better than last year and both *Oidium Heveae* and *Hevea Thrips*, though present, had not caused so much damage in the lower, shaded branches as was reported last year.

The rubber areas north of Sungei Patani had obtained an excellent foliage, though no fewer than six estates reported a mild attack in the lower branches of later-wintering trees. Here

again the activity of insect pests and Helminthosporium were in evidence.

PAHANG

This State was not visited by the writer but the reports received from estate managers indicate that a general improvement on last year's foliage is noticeable while only three estates reported the presence of a mild attack of Oidium in the later-wintering trees.

SUMMARY

The general improvement in the health and vigour of the foliage of rubber trees mentioned in the 1935 report was maintained throughout the 1936 refoliation season.

Though heavy rains in January delayed the wintering or fall of the old leaf by about four weeks the subsequent period of drought—about six weeks—caused a severe wintering and a rapid refoliation so that in many districts a new, healthy, mature foliage had developed before the dull showery weather, favourable to the leaf mildew fungus *Oidium Heveae*, arrived in mid-March. The central States were again the seat of greatest mildew activity but it was in all cases less severe than has been recorded in the past few years.

Again, owing to lack of virulence of the mildew fungus under drought conditions, the sulphur-dusting experiments carried out in various parts of the country indicated no decisive improvements in foliage or yield of rubber following such treatment.

6th May 1936.

NOTES ON TROPICAL SOILS WITH SPECIAL REFERENCE TO MALAYAN SOILS FOR RUBBER CULTIVATION*

BY

R. A. Hamilton

Soil is the product of climate and vegetation acting on rocks. The climatic factors are both mechanical and chemical and, in the humid tropics, the main factor is chemical, in the form of rain water carrying dissolved carbonic and nitric acids. Erosion is the chief mechanical factor.

The following remarks apply only to soils of the humid tropics.

The continual high rainfall and temperature facilitate comparatively intense chemical action and rock weathering. Rocks, which in the tropics are weathered to a depth of thirty to forty feet, are in temperature countries either bare or covered with a very shallow layer of soil. This formation of deep soil is however, accompanied by removal of large quantities of plant food by leaching.

With the first signs of weathering, lower forms of plants appear and, as weathering advances, these are replaced by higher plants, and eventually the vegetation takes the form of the tropical rain forest found in Malaya.

Before the heavy leaching has removed the bulk of the plant nutrients, a certain amount is taken up by the early vegetation, also a certain amount of plant food is brought up from lower layers by deep rooting forest plants; much of this plant food is returned to the surface layer by decaying vegetation and is taken up again by succeeding vegetation.

It is estimated that in a tropical rain forest the yearly production of fresh organic matter is about one hundred tons per acre, yet the depth of forest litter is only a matter of an inch or so, and the depth of soil humus is usually not more than four inches. This is due to the fast rate of organic decomposition which, even in heavily shaded forest, is almost as fast as formation. In this way a continuous forest cycle is formed with young plants living mostly on the debris from older ones. In addition a certain amount of atmospheric nitrogen is added to the soil by nitrogen-fixing bacteria, and also a certain amount of nitrogen is deposited in the form of nitric acid in the rains following thunder-storms.

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* Lecture given to the Nilai-Labu and Seremban-Rantau-Port Dickson branches of the Incorporated Society of Planters in April and May, 1936.

The soil usually found underlying primeval forest, therefore, consists of a thin layer of humus, usually not more than six inches deep, overlying a leached soil, many feet deep. The "inexhaustible fertility" of tropical soils inferred from the luxuriant forest vegetation is seldom found.

There are areas throughout the tropics where more permanently fertile soils occur. These are either deep alluvial clay soils, formed from the weathered products of igneous rocks, or soils formed as the result of recent volcanic activity. Examples of the latter are found in Netherlands India and in the West Indies. In the West Indian Island of St. Vincent a particularly striking example occurs. In 1902 a large portion of the north half of this island was covered with ash from eruptions of the Soufriere, and in a few years, crops were re-established on many of the damaged estates. When visiting the island in 1933 the writer was shown over an excellent coconut plantation on the lower slopes of the Soufriere where, owing to the high content of fresh minerals still available for decomposition, the soil will remain fertile for many years.

Geology and Topography

Next in importance to climate in deciding soil type are the geological and topographical features of the land.

In a country of uniform climate, soils formed in situ are closely related to the underlying rocks, as will be seen later when Malayan soils are considered.

Rocks are of three main types.—

1. Igneous Rocks. These are crystalline and volcanic rocks such as granite, andesite and basalt. These rocks are fairly uniform as are also soils formed from them.
2. Sedimentary Rocks. Limestones, and rocks formed from the weathered products of igneous rocks which have been transported and deposited in the form of sediments, such as sands, silts and clays. As would be expected, soils formed from these deposits are very variable.
3. Metamorphic Rocks. When sediments come under the influence of heat and pressure metamorphic rocks are formed and, as in the case of sedimentary rocks, are very variable, soils formed from them being often poor. Quartzite rocks belong to this class.

Examples of soils formed from each of these rock types will be given in the discussion on Malayan soils.

Soil Fertility

The agricultural value of a soil depends on its position and fertility; a highly fertile soil in an inaccessible position is naturally useless.

Soil fertility depends on the following main factors:

1. Water supplying capacity
2. Nutrient supplying capacity
3. Oxygen supplying capacity
4. Root space
5. Absence of harmful factors
6. Temperature

Plant growth is limited to a greater or lesser extent by each of the above factors and, in assessing the fertility of a soil, or in recommending any treatment to improve fertility, each of the above factors must be considered.

The relative importance of each of the factors is greatly influenced by the crop in question, but for most tropical crops the water relationships of a soil are of paramount importance. Rubber, for example, must have an abundant water supply, yet it will not stand waterlogging.

Root space is closely bound up with the water question.

A satisfactory method for assessing the value of a soil for agricultural development, or its suitability for a particular crop, has been evolved by the Soils Department of the Imperial College of Tropical Agriculture, Trinidad, under the direction of Professor F. Hardy, and is roughly as follows.

Soil profiles are exposed in pits six feet deep which are carefully described as to colour, texture, moisture, root development, depth of water table if present; particular attention is paid to the occurrence or otherwise of pans, stones, sand layers etc. The surrounding vegetation is carefully described. Soil samples are taken from different layers, usually 8 to 12 in number, and examined in the laboratory. Determinations are made which aim at measuring the texture, moisture relationship, nutrient supply and the detection of harmful factors if present. The values obtained are plotted to scale on profile cards by using suitable colours; samples of the soil, finely ground, are mixed with clear varnish and painted on the cards opposite the corresponding set of colour values. (*Vide* Figs. I—V facing page 42).

Where any particular crop is concerned pits are examined and soil samples are analysed from as many representative areas as possible, especially from those which are known to be good and those which are known to be bad. All available information as regards growth, yield, quality of crop and susceptibility to disease on each site is noted. Where any particular plant food deficiency is indicated manurial experiments are laid down to test this. By this means it is possible to determine the soil environment best suited to the crop in

question and, knowing what is required, to improve poor environments by means of manures or cultivation if it is economic to do so.

Analyses of leaves of various crops have also recently been used in conjunction with soil investigations and field experiments; the results have been found very useful in helping to solve fertility problems in the cultivation of such crops as cocoa and citrus.

A large amount of data has been collected according to the above methods from the various West India Islands, British Guiana and British Honduras, and the soil conditions best suited to the growth of such crops as sugar cane, cocoa, citrus, bananas and coconuts have been defined. Almost every type of soil found in the humid tropics has been studied, either from the point of view of agricultural development, or in relation to one or other of the aforementioned crops.

Soils such as many of the inland soils of Malaya have been found to be of low permanent fertility, with the bulk of the nutrients confined to the top layers. When the forest is cleared and these soils are exposed for agricultural development, deterioration is rapid, and soon they require continued application of manures, if economic yields are to be obtained.

The importance of soil examination, before areas of humid tropical soils are opened up for agricultural development, has been emphasised by this and other tropical soil work. Owing to the great variation and general low permanent fertility of humid tropical soils, many areas have been planted with various crops which are very unsuitable. Dr. P. Vageler who has had twenty years' experience in tropical soil work in various countries, estimates that 75 per cent of all failures in agricultural enterprises in the tropics is due to planting on unsuitable soil, because

i. The soil is not worth cultivating.
ii. The soil is not suited to the crop.
iii. The soil requires heavy outlay on manures.

The position is usually made worse by the fact that early growth is good even on poor soils, but is generally followed sooner or later by deterioration or failure of the crop.

In days of high prices such facts are not apparent, but when prices settle down as they eventually do in the case of most crops, it becomes a case of small profits and large turnover, entailing low cost of production, where high yield per acre and low cultivation costs—which are only obtained on reasonably good soils, properly treated—are all important.

Malayan Rubber Soils

The following observations on Malayan rubber soils are of a preliminary nature. They are derived from notes made from the examination of some 200 soil profiles in different parts of Malaya,

during the past six months by Hardy's methods. All available information concerning the rubber trees on each soil type has been collected, and this has been considered in relation to profile description, and soil and leaf analyses, carried out by the analytical staff of the Soils Division.

The following arbitrary scheme for assessing soil factors is derived from a similar one formulated by Hardy for West Indian Soils, and has been modified to suit Malayan conditions in respect of rubber cultivation.

It will probably be necessary to revise some of these values when results are available of field experiments on rubber which are being laid down on the various soil types.

Index of Texture (I.T.)

60	—	56	Heavy clay
55	—	41	Clay
40	—	31	Silt
30	—	21	Loam
20	—	11	Sand
10	—	1	Light sand

Reaction (pH)

9.0	—	8.0	Very highly alkaline
7.9	—	7.6	Highly alkaline
7.5	—	7.1	Alkaline
		7.0	Neutral
6.9	—	5.5	Slightly acidic
5.5	—	4.0	Acidic
4.0	—	3.0	Highly acidic
3.0	—	2.5	Very highly acidic

Organic Matter (O.M.)

per cent.			
8.0	—	5.0	Very high
5.0	—	3.5	High
3.5	—	2.5	Medium high
2.5	—	1.5	Medium
1.5	—	1.0	Medium low
1.0	—	0.5	Very low
0.5	—	0.0	Negligible

Total Nitrogen (N)

per cent.			
0.55	—	0.35	Extremely high
0.35	—	0.25	Very high
0.25	—	0.15	High
0.15	—	0.12	Medium high
0.12	—	0.08	Medium
0.08	—	0.05	Medium low
0.05	—	0.03	Low
0.03	—	0.00	Very low

Conductivity ("Nutrients")

300 —	100	Very high
100 —	70	High
70 —	50	Medium high
50 —	40	Medium
40 —	30	Medium low
30 —	20	Low
20 —	0	Very low

Available Phosphate (P_2O_5)
(Truog N/100 H_2SO_4)

Parts per million

100 —	50	Very high
50 —	40	High
40 —	30	Medium High
30 —	20	Medium
20 —	10	Low
10 —	0	Very low

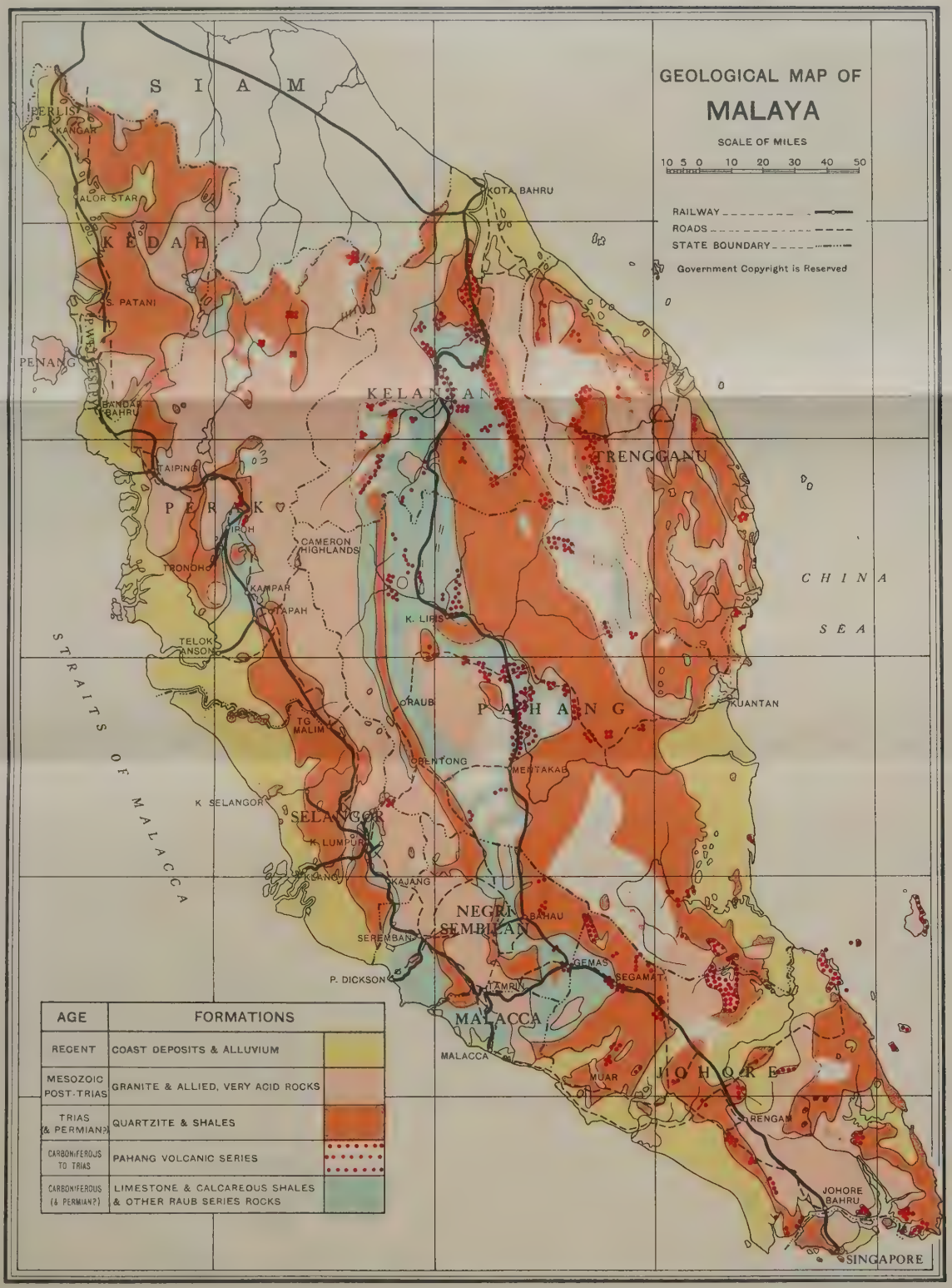
Available Potash (K_2O)
(N/2 Acetic acid)

Parts per million

1000 —	500	Extremely high
500 —	350	Very high
350 —	280	High
280 —	200	Medium high
200 —	120	Medium
120 —	80	Medium low
80 —	50	Low
50 —	20	Very low
20 —	0	Extremely low

" Nutrients " values which exceed 700, as is the case in the lower layers of some coastal clay soils, probably indicate the presence of free acid or a high concentration of salts, both of which inhibit root growth. Values over 700 can be taken to indicate bad drainage conditions.

The phosphate status of Malayan soils is puzzling. When Truog's method, which is used in the West Indies for determining available phosphate, is applied to these soils, values of less than one part per million are obtained in the case of all inland soils. Hardy regards values of less than twenty parts per million as being low, and it would appear that the phosphate status of Malayan soils is very low. As a result of the very low values obtained the strength of the extracting acid has been increased five times, from 0.002 to 0.01 per cent sulphuric acid and even then the values obtained for inland soils are mostly below twenty, while virgin soils do not seem to be appreciably better in this respect than cultivated soils. Coastal clay soils as a



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rule are much higher in available phosphate than are inland soils, and this high soil phosphate is reflected in a high phosphate content of rubber leaves from rubber trees growing on coastal soils, as compared with a low phosphate content in leaves from trees growing on inland soils.

The phosphate question is receiving special attention in the Soils Division, where new methods for determining available phosphate are being investigated and field experiments are being laid down to test the findings of the soil analyses.

Geology and Topography of Malaya

The topography of Malaya is mountainous with the ranges running mostly in a North-South direction, the hills rising sharply from the plains, and consequently the rivers remove much soil material, which is deposited at lower levels. Scrivenor's book and map on the geology of Malaya considerably simplifies soil work in this country, and all references to Malayan geology are taken from this work. The chief geological formations found in Malaya are :—

1. Granite
2. Quartzite
3. Limestone
4. Pahang Volcanic Series
5. Coastal Deposits and Alluvium

The distribution of the above formations is shown in the Geological Map.

Granite Soils

According to Scrivenor the average depth to which granite is weathered is about 30 feet. The weathered product is a yellow, orange or red, soft mass, running from soil through soft, rotten rock to hard rock. Sometimes the depth of weathering is much shallower and sometimes the weathered product changes abruptly from soil to hard rock and, in some cases, boulders are found which are very resistant to weathering.

An example of this typical deep weathering of granite is seen from a profile exposed in a road cutting at the 14½ mile post on the Kuala Lumpur—Tanjong Malim Road, and is as follows :—

Depth	0 — 6 ins.	Dark brown humic loam
	6 ins.— 3 ft.	Light brown sandy loam
	3 ft. — 6 ft.	Yellow sandy loam
	6 ft. —13 ft.	Red sandy loam with very coarse sand grains
	13 ft. —17 ft.	Red decomposed rock and soil
	17 ft. —19 ft.	Rotten rock
	19 ft. downwards—	Hard granite rock.

For agricultural purposes, as far as rubber cultivation is concerned, only the top 6 feet of soil need be considered. As can be seen from the above profile the top 6 feet is a uniform textured sandy loam soil, drainage and aeration are good and the soil contains sufficient clay to hold a considerable amount of moisture. There are no pans or hard layers which would hinder root development. The nutrient status of this soil is only medium, especially in regard to phosphate and nitrogen, and the bulk of the nutrients are concentrated in the top thin humic layer.

According to Vageler, for good growth and yield of rubber on soils where the water table is deep, as in the case of most upland soils, 5 feet of uniform soil of good texture is necessary. Observations on rubber in Malaya are in agreement with this.

Rubber trees appear to do very well on granite soils if planted on virgin land; growth and yield are usually very good, but the rate of bark renewal, and consequently the yields in many cases fall off when the rubber is about 20 years old. The good initial growth and yield of rubber on these soils is probably due to reasonably good texture, combined with a fair supply of nutrients in the virgin soil. Deterioration is mostly due to the loss of a large amount of the top humic layer from erosion and exposure to the sun. Granite soils should be kept covered at all costs in order to prevent erosion and baking of the top soil. The chief effect of cover is to retain what is already in these soils, and to maintain good moisture conditions by preventing water running off and by inducing percolation.

On deteriorated granite soils, the value of "forestry methods" as practised on Malayan rubber estates is limited from the point of view of adding organic matter and nutrients.

In Malayan forests where 100 tons of fresh organic matter per acre per annum are produced, and where shade is much denser than on a rubber estate, the depth of humus is seldom more than four inches, and often less, after years of forest growth. On this account it is suggested that the amount of plant food added even by good forestry cover is very small, especially in regard to minerals; for this reason it is suggested that manuring combined with forestry is necessary on deteriorated soils. The effect of the manures will be greatest if they are added before much deterioration in the rubber has set in It is much easier to keep rubber trees in good condition with manures and forestry, than to rejuvenate deteriorated rubber, and should cost much less. Nitrogen and phosphate are necessary, and phosphate is best applied in the form of large dressings of a good type of rock phosphate. Phosphatic manures should be well incorporated with the top layer of soil.

In steep ravines granite soils are usually white and sandy and of poor quality, but in valleys they are usually deep and fairly fertile.

As has already been stated, granite soils in the virgin state produce very good growth of rubber trees and, in view of the fact that unless they are well covered deterioration is rapid and also that considerable damage is done by burning, the possibility of planting on these soils, or in fact on all inland soils, without burning, is worth considering. In this way the top humic layer will be maintained and a good forest cover can be established from the beginning.

Granite soils carrying good rubber trees are found in parts of South Kedah, North and Central Perak, Selangor, Negri Sembilan, especially in the Labu Valley and small areas in Central Johore.

The poor rubber trees on much of the granite in Malacca and South Johore are due to previous cultivation and erosion.

TABLE I

Some Granite Profiles

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3	53	23	4.6	33	3.6	0.13	9	229	Old rubber trees well grown and yields were good but bark has deteriorated badly. Needs to be kept covered and should have been manured earlier.
6	43	25	4.6	21	2.2	0.07	7	149	
12	43	26	4.7	22	1.7	0.05	9	181	
24	43	26	4.7	21	1.6	0.05			
3	74	4	4.3	62	4.6	0.12	6	183	Sandy granite soil, old rubber trees fairly good but will need manuring. Low phosphate. Although this soil is high in sand it contains a fair amount of clay.
6	65	9	4.4	40	3.3	0.08	8	143	
12	64	7	4.2	72	2.7	0.05	7	159	
24	63	10	4.2	45	2.4	0.05			
36	58	13	4.2	58	2.4	0.05			
48	54	12	4.2	74	2.1	0.04			
60	52	14	4.2	63	2.2	0.03			
3	58	10	4.2	105	8.4	0.21	5	288	Granite forest soil, high "nutrients" and potash. Note sharp drop in nitrogen below 3 ins. Low phosphate.
6	56	12	4.0	187	8.2	0.08	8	280	
12	52	16	4.0	249	3.3	0.06	6	265	
24	56	14	4.0	199	2.5	0.06			
36	50	14	4.5	218	2.4	0.05			
54	43	18	3.8	353	2.1	0.03			
72	50	15	3.8	374	2.0	0.03			
3	49	20	3.6	202	5.4	0.21	9	412	Granite forest soil, "nutrients" good. Low phosphate.
6	40	19	3.8	161	3.2	0.12	7	203	
12	47	16	4.0	144	1.8	0.10	6	229	
24	45	19	4.0	148	1.9	0.07			
36	50	16	4.0	177	1.0	0.05			
54	50	11	4.1	107	1.1	0.05			
72	42	18	4.0	116	1.0	0.06			

Note the high "Nutrients" and potash (K_2O) values in forest soils as compared with cultivated soils.

Quartzite Soils

In contrast to granite, quartzite rocks are very variable as are also soils formed from them; according to Scrivenor, they are more resistant to weathering than granite.

In general quartzite soils are low in plant food especially in respect of nitrogen and phosphate, but may be better in this respect than granite soils. The same general remarks as to deterioration, forestry methods and manuring apply to these soils as to granite.

A more serious objection to quartzite soils, than their low nutrient status, is the frequent occurrence in these soils of an undesirable texture.

The soil profiles already examined show that the following types of quartzite soils occur on Malayan rubber estates, although the division between the different types is not always distinct.

1. *Yellow-red or red loamy soils*, of good depth and texture, and free from sand layers or layers which impede root development. These soils are often better than the granite soils already described. Examples of these soils have been found in South Kedah, parts of North and Central Perak and North Selangor.
2. *White or grey sandy soils*, devoid of any crumb structure. Sometimes these soils are dark on top, giving the impression of having a high content of organic matter, but this is usually due to carbon. The sand increases in coarseness at about five feet and is sometimes cemented into hard pans.

   Rubber on this type of land is usually stunted in growth, yields are low and bark renewal poor, foliage is usually sparse and yellow. Often strips of this soil run through good soil such as (1).

   Water as well as plant food on these soils is a limiting growth factor and, on this account, manures in most cases are of doubtful economic value. A cover is most important. If manures are used on these soils a complete manure is necessary; the potash content of leaves of rubber growing on these soils is very low in comparison with that of leaves from other inland soils.

   As rubber trees on these soils are usually the poorest on an estate, these areas are often included in replanting programmes, but this procedure is not to be recommended, and in every case replanting on these soils should at first be on an experimental scale. Areas of these soils are found in South Kedah, South Perak and in the Sungei Buloh district of Selangor.
3. *Yellow-red or red loams resembling* (1), but with laterite* stones in the top six feet. These soils are again of two classes.

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* In all cases the term laterite is used with the popular Malayan meaning.

(*a*) The laterite stones are not in the form of a compact layer. These soils are usually almost as good as (1). They are found throughout Malaya where quartzite rocks occur.

(*b*) The laterite is in the form of a hard compact layer, likely to check the development of the tap-root. If the laterite layer is about 3—4 feet from the surface, the rubber trees are fair but not good. If the layer is within 18 ins. of the surface, the trees are poor and for rubber cultivation these soils are of doubtful value.

Areas of these soils occur in Central Kedah, and in parts of Selangor, Negri Sembilan and Johore.

TABLE II

Some Quartzite Profiles

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3	48	20	3.7	260	6.6	0.30	6	491	Forest soil on good type of quartzite. Texture good and no pans. Potash high but phosphate low.
6	46	21	3.8	211	3.1	0.16	4	415	
12	45	22	3.9	274	3.4	0.12	4	321	
24	47	22	4.0	175	2.1	0.09			
36	45	20	4.0	209	1.6	0.07			
48	43	27	4.0	170	1.6	0.07			
60	42	22	4.2	139	1.4	0.05			
72	48	19	4.2	125	1.4	0.04			
3	32	33	4.2	20	3.3	0.12	8	208	Old rubber trees fairly good; some laterite but not compact. Low phosphate.
6	27	29	4.3	20	1.3	0.07	5	127	
12	26	28	4.2	14	1.3	0.06	6	140	
24	39	22	4.2	15	1.2	0.05			
36	53	13	4.6	11	1.1	0.03			
48	45	18	4.4	12	1.0	0.03			
60	38	20	4.5	11	1.0	0.03			
3	45	27	5.1	75	11.5	0.30	11	170	Old rubber trees very good. Good quartzite, no laterite. Note high N and O.M. in surface soil.
6	40	24	5.0	67	6.4	0.23	11	158	
12	73	3	5.0	45	1.3	0.08	10	100	
24	70	7	5.0	25	1.4	0.07			
36	68	8	4.9	30	0.8	0.05			
54	61	10	4.9	38	0.4	0.04			
72	60	10	5.2	25	0.4	0.03			
3	89	0	5.3	26	1.3	0.08	9	113	Old rubber trees very poor. Poor sandy soil. Note very low N and O.M.
6	90	0	5.5	34	1.1	0.04	9	115	
12	93	0	5.3	31	0.9	0.04	9	102	
24	92	0	5.4	24	0.6	0.03			
36	93	0	5.4	33	0.6	0.02			
54	94	0	5.4	37	0.5	0.02			
72	96	0	5.5	44	0.2	0.02			

Note the high "Nutrients" and potash (K_2O) values in forest soils, as compared with cultivated soils and the sharp decrease in nitrogen with depth.

4. *White or yellow clay soils.* These soils carry fair rubber trees if the clay is not too heavy and compact as is the case with the higher level yellow clays. In the case of the low level, stiff, white clays the rubber trees are poor, growth is slow and bark is hard with poor renewal. Nitrogen and phosphate will probably improve the trees on these soils but, in addition to manuring, every effort should be made to improve the texture. A cover is necessary to prevent the hard drying-out of the top soil, which occurs if these soils are exposed. In the case of young rubber trees continued digging in and manuring of the cover, although expensive, might repay the extra cost. Large areas of these soils occur in the Bahau district of Negri Sembilan and in parts of Pahang.

LIMESTONE SOILS

(*a*) *Free lime in surface soil.* These soils are of very limited occurrence; they are found in Central Perak near Ipoh. They are chocolate brown in colour and have a good loamy texture. The pH may be over 8 which makes them unsuitable for rubber cultivation.

Leaves from trees growing on these areas have abnormally high calcium contents. Heavy dressings of sulphur might be of value in improving these soils but would probably not be economic.

(*b*) *No free lime in surface soil.* These are red loamy soils and their value varies according to the amount of laterite they contain. If there is only a small amount of laterite and this is not in a compact layer, the soil is fairly fertile and grows good rubber trees. In most cases however they contain much laterite which greatly reduces their value.

The nutrient status is fair but in most cases rubber trees growing on these soils will benefit from applications of nitrogen and phosphate.

When, as has happened on large areas, erosion has greatly reduced the already thin layer of laterite-free topsoil, the resulting soil is very poor.

Areas of these soils are found in South Negri Sembilan, Malacca and Johore.

Often the limestone is covered by a cap of quartzite rock and the resulting quartzite soils are similar to 3 and 4, already described.

TABLE III

Some Limestone Profiles

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3	37	32	4.3	34	3.9	0.18	12	179	Old rubber trees fair; good profile for limestone, laterite is not compact.
6	32	30	4.3	23	3.3	0.15	9	140	
12	33	34	4.3	21	2.6	0.12	9	119	
24	33	31	4.3	19	2.0	0.08			
36	48	19	4.5	19	1.6	0.06			
48	41	31	4.6	16	1.2	0.05			
60	36	24	4.8	11	1.2	0.05			
3	23	25	3.8	212	5.2	0.11	7	431	Forest soil, high "nutrients." Low phosphate. Compact laterite layer below 24 ins. will retard growth.
6	22	23	3.8	229	4.5	0.10	7	375	
12	31	28	4.4	144	4.3	0.13	6	431	
24	7	41	4.1	101	4.0	0.09			
36	7	42	4.1	169	2.8	0.08			
48	9	42	4.2	141	2.8	0.07			
6			8.4	138	2.3	0.14	12	343	Lime in surface soil; note very high pH. Rubber trees poor and chlorotic.
24			8.6	138	2.5	0.18	15	389	

Pahang Volcanic Soils

The rocks from which these soils are formed occur mostly in Pahang and Kelantan, and as yet have not been developed for rubber cultivation to any extent. Small areas are found in Johore; an outcrop occurs along the Buloh Kasap—Segamat Road. This soil is formed from basalt and is deep brownish-red in colour; it has an excellent loamy clay texture, is free from stones and is uniform to at least 15 feet. The rubber trees on this area are old, but are still very high yielding, and bark and foliage are very good. The trees are very large resembling those on good coastal clays, root development is excellent, many fine roots being found at six feet, which is very unusual. Root disease is fairly abundant. The dry rubber content of the latex from this area is considerably higher than that of the adjoining areas. The plant food content of this soil is high except in the case of available phosphate, but the value shown for phosphate may be too low. Phosphate is readily fixed in this type of soil in a comparatively insoluble form, and it is probable that some of this fixed phosphate is available to the rubber roots.

The relatively high organic matter and nitrogen values, even at five feet, are worthy of note.

TABLE IV

A Profile on a Basalt Rock of Pahang Volcanic Series

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3	20	32	4.3	215	8.6	0.24	5	365	Old rubber trees very good, but much root disease. Very good texture and uniform to 15 feet. Very deep lateral root development.
6	13	38	4.2	184	3.7	0.15	6	354	
12	15	37	4.2	167	3.5	0.10	5	314	
24	12	37	4.3	198	3.1	0.10			
36	12	38	4.3	210	2.5	0.10			
48	11	40	4.5	149	2.7	0.08			
60	12	40	4.6	140	2.5	0.07			

Area under cultivation since 1908. Note high "nutrients" even at 5 ft. N. and O.M. good throughout the profile. Low phosphate due probably to high fixation.

Very good inland soil.

Deterioration of Inland Soils due to previous Cropping

Where inland soils have grown other crops before being planted with rubber trees they are considerably poorer and grow much poorer trees than the corresponding virgin soil. Deterioration is due to cultivation and exposure, as well as to removal of plant food by the previous crops. The plant food requirements of tropical crops vary greatly; pineapples remove large amounts of plant food, especially potash. It is estimated that a pineapple crop removes annually the equivalent of 5 cwts. of sulphate of potash per acre from the soil.

Alluvial Soils

(*a*) Inland

These soils have not yet been investigated to any extent by the profile method; they are found chiefly in Central Johore and North Kedah. Variation seems to be considerable, as would be expected, and they resemble quartzites.

(*b*) Coastal Deposits

Coastal soils are conveniently divided into two types,

(1) Clays (2) Peats

(1) Clays

Clays are the most important of this group, as they constitute the largest area of coastal rubber soils. These soils vary greatly both in texture and chemical composition. They are the richest soils in Malaya and, with reasonable treatment, should remain fertile for many years.

These soils are usually grey or grey-brown in colour above the water table, the texture is usually fairly open for clay soils and the plant food content is very good. The pH is usually above 4 which

is quite suitable for rubber cultivation. In the zone of fluctuating water table they are bluish with red or yellow mottlings and show increased acidity. The layer permanently below water is blue with a very low pH, the very high "nutrients" figure probably indicating the presence of free acid.

TABLE V

Some Coastal Alluvium Profiles

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3	19	41	4.4	65	8.0	0.27	75	396	Old rubber trees very good. "Nutrients" high and soil well drained, no acidity increase at 36 ins. Rubber trees replanted on similar soil without manuring are very good.
6	22	40	4.3	47	6.4	0.25	71	333	
12	11	40	4.0	47	6.1	0.21	32	330	
24	7	41	4.0	58	4.5	0.15			
36	19	33	4.0	101	2.3	0.09			
3	11	42	4.1	56	7.9	0.31	30	354	Old rubber trees fair, drainage bad; note increase in acidity below 12 ins. and free acid below 24 ins.
6	18	40	4.1	73	7.4	0.27	28	189	
12	29	39	3.6	114	6.7	0.22	26	255	
24	29	37	3.4	231	7.4	0.21			
36	37	43	2.9	2269	8.3	0.22			
3	10	50	4.6	65	10.5	0.29	103	396	Old rubber trees fairly good, drainage fair, "nutrients" high, slight increase in acidity at 36 ins.
6	10	41	4.4	47	5.8	0.14	34	322	
12	8	45	4.1	75	5.2	0.12	12	225	
24	6	41	3.8	82	4.6	0.12			
36	9	43	3.6	249	3.0	0.08			
3	16	31	6.7	317	3.2	0.15	292	859	Old rubber trees good, recently replanted, low stand owing to disease. Sea shells mixed with soil; note pH almost neutral and very high "nutrients." Drainage very good.
6	16	33	6.7	297	5.4	0.22	205	848	
12	17	31	6.7	150	4.0	0.15	129	482	
24	10	32	6.7	183	1.5	0.13			
36	21	23	7.3	174	0.9	0.03			
3	21	39	5.4	53	4.5	0.22	402	338	Area very close to above, old rubber trees very good, drainage good and "nutrients" high.
6	13	39	5.0	47	3.9	0.17	172	320	
12	8	41	4.4	60	2.7	0.13	35	247	
24	6	43	4.0	95	3.4	0.09			
36	6	44	3.5	189	3.8	0.10			
3	8		4.0	94	54.0	0.89	12	372	Shallow layer of peat over clay, poor bark in this area.
6	8		4.0	80	35.1	0.49	8	316	
12	24		3.8	98	13.0	0.19	6	222	
24	7		3.6	182	12.7	0.18			
36	6		2.9	710	9.9	0.18			

The height of the water table varies greatly and is the limiting growth factor in these soils. If drainage is good and the average yearly water table is below 42 inches, they are usually very fertile. On one Malayan estate, 1,400 acres of this type of soil have been replanted without the use of manures. The land was very well drained in advance of replanting, and creeping cover was used which has brought the top soil into excellent condition. Growth and general vigour of the trees are excellent.

On this estate there is a small area of very stiff clay soil where growth is very poor, manures are of no value but covers may after a time help to open the soil and improve growth. Extra draining of this soil does not help matters since water does not percolate through it.

In some coastal clays sea shells are mixed with the soil; an example is shown in Table V. The pH is about 7 and the plant food content is high; the soil is of good texture and well drained. It grows good rubber trees but not better than soils of pH 4.5.

Thin, loamy or peaty layers are sometimes found overlying clay, and these soils are usually good if the layer of peat is thin.

(2) Peat

Areas of peat are found where the soil has been waterlogged for a considerable time. The peat usually overlies clay and its agricultural value is greater the thinner the peaty layer.

Little is known about the agricultural relationships of tropical peats. They must be drained, but when drained the crop may suffer from drought in dry weather.

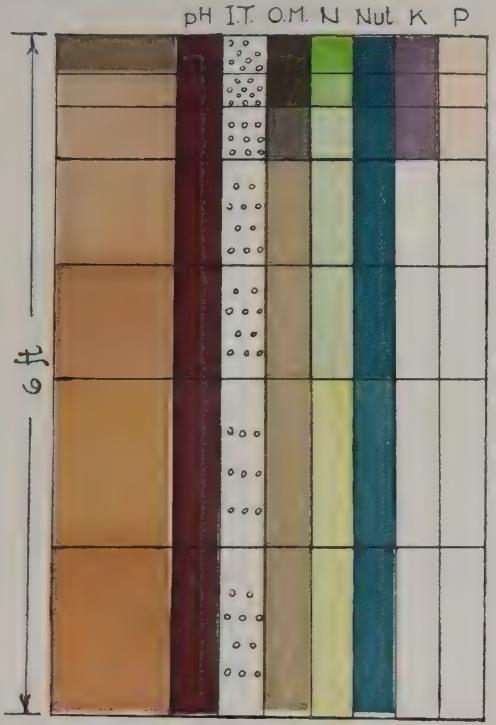
TABLE VI

Profiles on Peat

Lower depth inches	Sand per cent	I. T.	pH	Nutrients	O.M. per cent	N per cent	P_2O_5 p.p.m.	K_2O p.p.m.	Remarks
3			3.9	83	34.6	0.72	31	226	36 ins. of peat over clay, young rubber trees fairly good, probably needs potash and phosphate. Drainage good.
6			3.7	100	36.5	0.55	25	183	
12			3.6	157	46.2	0.57	23	161	
24			3.7	185	39.4	0.93			
36			3.6*	250*	75.0*	0.94*			
48			3.5	1240	9.9	0.10			
3			3.6	143	29.0	0.54	8	222	Old peat area. Badly drained, note acid soil. Old rubber trees poor. †Harmful amount of acid below 12 ins.
6			3.5	128	18.0	0.35	9	253	
12			3.5	207	16.0	0.35	9	309	
24			3.0	876†	16.0	0.32			
36			2.9	2615†	18.0	0.31			

*As the amount of soil available for analyses was too small these figures are calculated from data available.

Fig. I.



Soil Type: Granite, sandy loam.

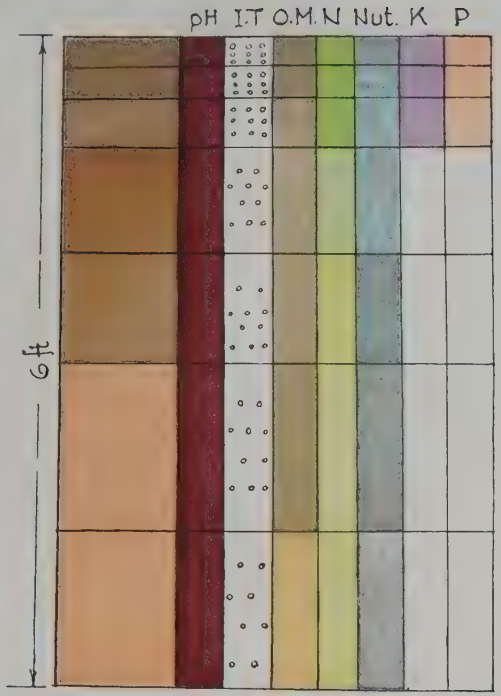
Remarks: Forest soil. Good texture. K and Nut high. N and O.M. high in topsoil. P low.

Fig. II.

Soil Type: Granite, sandy loam.

Remarks: Under Rubber 25 years. Good texture.

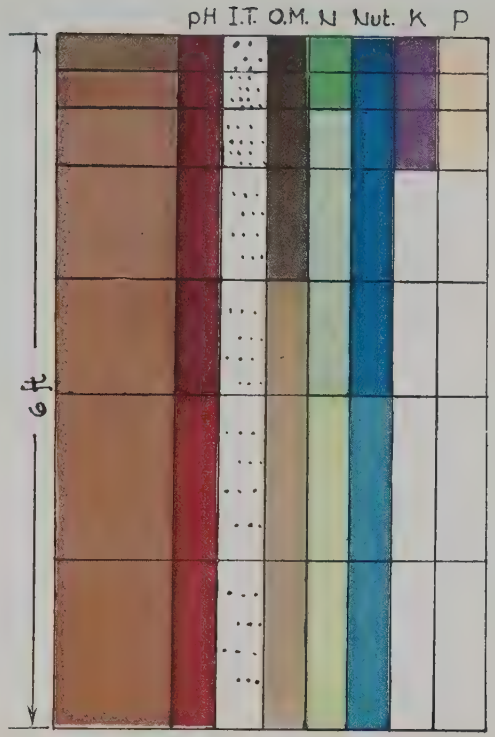
Fig. III.



Soil Type: Quartzite, sandy loam.

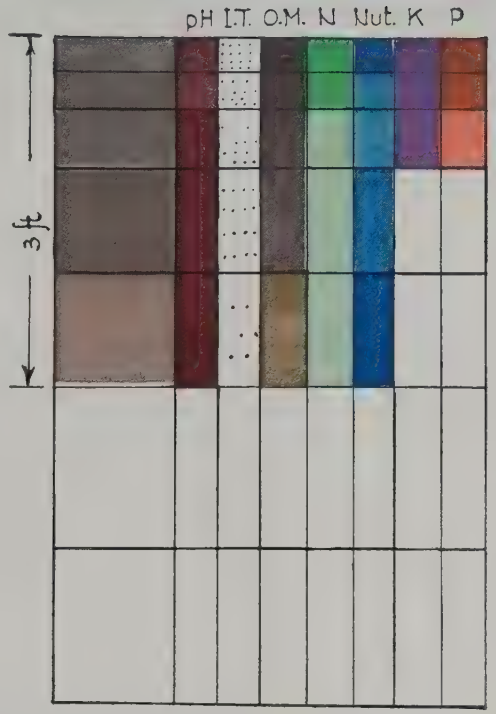
Remarks: Under rubber 25 years. Texture bad, excess sand. Plant food low.

Fig. IV.



Soil Type: Pahang Volcanic Series. Basalt clay loam.

FIG. V.



SOIL TYPE: Coastal Clay.

REMARKS: Cultivated over 30 years. Well drained. Texture good. N, P, K, Nut and O.M. high.

A serious objection is the great shrinkage of peat after draining, rubber trees planted before much shrinkage has taken place are usually left with the majority of the roots above ground, and the chief problem on peat is to keep trees standing. Manuring with phosphate and potash is advisable on peaty soil. Nitrogen is not necessary, rubber leaves from peaty areas having very high nitrogen contents.

PROFILE CARDS.

The fertility attributes of some typical Malayan soil profiles are shown in Figs. 1—5.

The analytical values are represented as follows :—

Reaction (pH)

Dark blue	...	...	Highly alkaline
Pink	...	...	Neutral
Dark red	...	...	Highly acidic

Index of Texture (I.T.)

Small number of circles	...	Sand
Large number of circles or small number of dots	...	Loam
Large number of dots	...	Clay

Organic Matter (O.M.)

Dark brown	...	...	High O.M.
Light brown	...	...	Low O.M.

Total Nitrogen (N)

Dark green	...	...	High N
Light yellow	...	...	Low N

"Nutrients" (Nut.)

Dark blue	...	...	High Nut.
Light blue	...	...	Low Nut.

Available Potash (K_2O)

Dark purple	...	...	High K_2O
Light purple	...	...	Low K_2O

Available Phosphate (P_2O_5)

Dark brown	...	...	High P_2O_5
Light orange	...	...	Low P_2O_5

Soil Analyses

Before concluding, a note on soil analyses is necessary.

Often soil samples are sent to the Institute from estates, with a request that these should be analysed, and as a result of analyses, that advice should be given on manures suitable for replanting or improving old rubber. It is impossible from soil samples sent in this manner to give any satisfactory advice. An inspection of the area is best, but if, as happens in many cases, that cannot be arranged at the time, some help can be given if the following information is given.

1. Position of area
2. Slope of land
3. Whether area was planted from jungle
4. Age of rubber trees
5. Any cultivation or manuring which has been carried out
6. Yields when the rubber trees were at their best and present yields (The tapping system should be given).
7. Condition of bark, foliage, etc.
8. Whether land is liable to water-logging
9. Any other relevant information.

In addition to this a few soil pits should be dug in different parts of the area and the following information given :—

1. Position of pit, *i.e.* top, bottom or side of hill
2. Colour of the soil profile exposed, any changes in colour with depth noted.
3. A rough idea of the soil texture, i.e. whether it is sandy, loamy or clayey.
   Compact laterite layers or loose laterite stones should be noted.
   Depth of water table, if visible.
4. Soil samples should be taken from one pit unless the area is very variable, when samples should be taken from each different type. The samples should be taken from the following layers 0-3 ins., 3-6 ins., 6-12 ins., 12-24 ins., 24-36 ins., 36-54 ins., and 54-60 ins.

A few, not more than six samples, should also be taken from the top six inches at various points in the area. All samples should be carefully labelled. This procedure will enable the soil type to be fixed and recommendations to be made accordingly.

In addition it will help in the survey of rubber soil types which, when taken in conjunction with field experiments, which are being laid down under the new experimental scheme on each soil type, will greatly advance our knowledge of the best treatment for rubber cultivation under various soil conditions.

THE CONSTITUENTS OF HEVEA LATEX

PART I

THE ISOLATION AND QUANTITATIVE DETERMINATION OF THE CONSTITUENTS

BY

K. C. ROBERTS

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Introduction

It is noteworthy that the very considerable body of published work on the chemistry of Hevea latex contains no record of attempts at a definitive analysis of this complex mixture of substances. This is the more remarkable since it is well known that certain non-caoutchouc constituents, which have been repeatedly shown to occur in latex, exert a profound influence on the properties of plantation rubber.

A review of the literature shows that evidence has been adduced for the presence in latex of no fewer than sixty different substances, but of these, very few have actually been isolated from latex and submitted to a severely critical examination. In the discussion even of the better-known non-caoutchouc constituents, such as the sugars, the proteins, the inorganic salts, and above all, the so-called "resins", there is always a certain amount of assumption and inference; and although more or less reliable determinations of the amounts of these constituents have been made, little is known of their mode of occurrence, or in most cases of their chemical composition. Moreover, an important group of ten to twelve substances, including the fatty acids and the natural

anti-oxidants of rubber, isolable from the acetone extract of crepe rubber, have not up to the present been isolated from latex itself, although their presence therein must clearly be inferred.

The present work describes a method for the isolation and quantitative determination of the constituents of Hevea latex (including the caoutchouc hydrocarbon) in the form in which they occur naturally. Such an analysis is necessarily a long and tedious process, involving as it does the isolation in a pure state of a considerable number of highly complex substances, but already the broad outlines of the constitution of this latex have been determined, and the existence of three hitherto unknown constituents has been established.

It is hoped in the near future to report the results of more detailed chemical investigations of the various constituents. Further it may be mentioned that applications of the method which are now in hand promise to throw light on a number of vexed questions. These include not only matters of immediate interest to the producer and the consumer of plantation rubber, such as the causes of variability, the constitution of clonal latices, and the effect of ammoniation, but also a group of fundamental problems including the structure of the caoutchouc hydrocarbon and the place of latex in the metabolism of the Hevea tree.

Experimental

General

Two fundamental requirements in undertaking this analysis are, first, that the raw material should be exposed to the least possible risk of undergoing fermentative changes, and second, that throughout the process any treatment, chemical or physical, which might be suspected of effecting chemical change in the latex or in its constituents should be avoided. It is felt that the procedure now to be described meets these requirements with a considerably greater degree of success than has hitherto been attained in the handling of the "total solids" of latex.

Drying of Latex

By arrangement with a nearby estate, the latex from a particular "task" is being submitted regularly in an untreated condition directly from the tapper to the Institute. On days when an analysis is commenced, this latex, immediately on arrival, is passed through a Monel metal sieve, and 1000 grams, in 100-gram portions, are immediately transferred through a burette to ten sheets of plate glass, each 54 cms. square. Each sheet is mounted in a substantial wooden frame to facilitate handling and levelling

operations. The latex is then carefully distributed so as to cover almost the entire surface of the glass in a more or less uniform film which thus averages 0.34 mm. in thickness. The frames are then exposed in the shade to a brisk current of air from a portable fan until the contents have reached a uniform translucence. As each frame attains this state, it is placed in direct sunlight for half-an-hour to complete removal of water and give a tough transparent film. By this procedure the entire operation of drying one litre of fresh field latex at atmospheric temperature is usually complete within three and one-half hours of receipt of the latex.

Dispersion of the dried Film

The dried films are removed from the frames in narrow strips, care being taken to avoid massing. As each strip is removed, it is placed in an aluminium or a glass vessel containing a mixture of carbon tetrachloride (7000 ccs.) and acetone (4500ccs.) which is kept well stirred during the operation and at intervals for some time afterwards. In this way a uniform dispersion of the total solids from the original litre of latex is obtained in a remarkably short time, the process being virtually complete in 1—2 hours. At this stage the dispersion is conveniently allowed to stand overnight in the closed vessel.

The use of the above mixed solvent has the additional advantage that the resulting dispersion is markedly less viscous than those obtained with the usual rubber solvents.

The dispersions thus obtained normally vary in concentration between the limits of 2.6 per cent (latex total solids 30 per cent) and 4 per cent (latex total solids 46 per cent), but it was judged advisable to use the above standardised procedure rather than to prepare day by day solutions of a fixed concentration and varying volume. The justification for this procedure will appear in the following.

Removal of Rubber

Acetone (4500 ccs.) is now added slowly in a uniform stream to the homogeneous dispersion, which is kept vigorously stirred. The caoutchouc is thus quantitatively precipitated in a fine flocculent form, carrying with it all the proteins, sugar, quebrachitol and inorganic constituents of the latex. The precipitate is allowed to agglutinate during 24 hours, at the end of which time it is readily separated as an opaque white lump from the supernatant clear yellow liquid. After being allowed to drain, it is carefully washed twice with a total of 500 ccs. of acetone, and the drainings and washings are added to the carbon tetrachloride-acetone

solution. The further treatment of this precipitated rubber is described later.

Isolation of the dissolved Matter

The carbon tetrachloride-acetone solution is now concentrated to small bulk by distillation from a steam-bath, and the residue is transferred quantitatively to a porcelain basin from which the remaining solvent is allowed to evaporate. The residue, weighing 10—20 grams, is a tacky, semi-fluid mass which varies in colour from yellow to deep red in different specimens. It will be referred to for brevity as "the organic-soluble constituents".

The mixed solvent readily lends itself to the recovery of carbon tetrachloride.

Isolation of the individual Organic-soluble Constituents

It has been found that this complex mixture of substances not previously isolated from latex is most readily separated into its primary components by selected solvent action. In outline, the method adopted involves extraction of the material first with water and then with rectified spirits. In this way are obtained (a) the water extract, (b) the alcohol extract, and (c) the residue, now to be described. As the detailed chemical examination of the resulting components is not yet complete, only a brief indication of their general nature is now given.

(a) *The Water Extract.* The organic-soluble constituents from one litre of latex are thoroughly extracted three times at room temperature by vigorous stirring with distilled water totalling 100 ccs. On drying the extract to constant weight on the water-bath a colourless crystalline residue is obtained which represents approximately 0.02 per cent by weight of the latex. This sometimes contains a small amount of quebrachitol, but in the main consists of the ammonium salt of a water-soluble aldehydic or ketonic acid. Pending its more complete description it will be referred to as the "ammonium salt".

(b) *The Alcohol Extract.* The material remaining after the water extraction is carefully kneaded five times at room temperature with a total volume of 210 ccs. of rectified spirits (3×50 and 2×30 ccs.). Evaporation of the combined extracts on the water-bath leaves a deep red oil containing more or less crystalline matter and constituting on an average 0.5 per cent by weight of the latex.

This material is now divided into components by treating it three times with petroleum ether (total volume 100 ccs.).

(i) *The petroleum ether-insoluble portion or "Ester."* This substance is relatively small in amount (approximately 0.05 per cent by weight of the latex) and when first isolated is a crystalline solid white or pale brown in colour. Its components are (a) a water-soluble aldehydic or ketonic acid and (b) a higher aliphatic alcohol. It is thought that the acid may prove to be the same as that occurring in the "ammonium salt" (above), while the alcohol gives evidence of being identical with that isolated from crepe rubber by Bruson, Sebrell and Vogt (1) and diagnosed by them as octadecyl alcohol. A small amount of quebrachitol is at times associated with this ester, and may be removed in virtue of its insolubility in absolute alcohol.

(ii) *The petroleum ether-soluble portion or "Fatty Acid Complex."* This comprises on an average 0.45 per cent by weight of the latex, that is 90 per cent of the alcohol-extractable material. As first obtained it is a deep red oil and is weighed in this form, but an alcohol solution of the material deposits almost quantitatively a homogeneous crystalline mass. Preliminary work indicates that the eight to ten component substances are isolable from the mixture only after hydrolysis. These facts, together with the mode of isolation of the material, provide the justification for classing it as a single latex constituent of the type of a "chemical complex" of considerable stability. The preliminary work further shows that the complex consists in the main of fatty acids, saturated and unsaturated, which are presumably identical with those isolated from the acetone extract of crepe rubber by Sebrell *loc. cit.* and by Whitby, Dolid and Yorston (2), and identified by them as oleic, linoleic and stearic acids. The remaining material is terpenic in character, and it is anticipated that further work will show it to consist of the substances diagnosed, in part by Sebrell and in part by Whitby (*loc. cit.*), as phytosterol, phytosterol glucoside, a hydrocarbon $C_{15}H_{24}$, a ketone $C_{15}H_{24}O$, and sterols $C_{27}H_{42}O_3$ and $C_{20}H_{30}O$.

(c) *The Residue.* This extremely interesting material, the existence of which either in latex or in rubber has hitherto been unsuspected, is one of the major non-caoutchouc constituents. It is widely variable from specimen to specimen in amount, in colour and in texture, but is in general a cream-coloured or brown plastic material constituting approximately 1 per cent by weight of the latex. It is weighed after the adhering alcohol has been allowed to evaporate at room temperature. Since its composition and characteristics are still being studied, mention will be made in this preliminary paper only of three observations: first, that the material is freely soluble in ether to a mobile solution; second, that it melts to a viscous liquid below 100°C; and third, that it

holds in combination a sulphur-containing acid. For convenience it will be called the "sulphur complex". It is interesting that a somewhat similar substance results when crepe rubber is allowed to react with thioglycollic acid at room temperature (3).

Note. In preliminary work, the water extraction (above) was followed by an extraction of the residue with dilute aqueous sodium carbonate. As this operation on no occasion gave evidence of removing acidic substances, it was discontinued.

Drying of the Precipitated Rubber

The acetone-washed mass of precipitated rubber (above), after being allowed to drain thoroughly, is repeatedly passed between cold rolls, the nip being gradually reduced until a thin pale-yellow sheet results. This is allowed to dry in air to constant weight. This product has the interesting property of dissolving almost without swelling in the usual rubber solvents to form opalescent, relatively mobile solutions. An investigation of its physical and mechanical properties is being made.

Removal of Non-Caoutchouc Substances from the Precipitated Rubber

The dried sheet of precipitated rubber contains the whole of the sugar, quebrachitol*, inorganic matter and protein of the original latex. The following method has been developed for the almost complete removal of these substances in the form of a single water-soluble complex, to be known as the "protein complex".

Ten grams of the precipitated rubber are dissolved in carbon tetrachloride (300 ccs.) in a two-litre round-bottomed flask, distilled water (1000 ccs.) is added, and the whole is vigorously shaken for some time. The flask is then placed in a water-bath until the carbon tetrachloride begins to boil, at which stage a current of steam is passed through the mixture until all the carbon tetrachloride is removed. The resulting aqueous solution and the rubber are now separated as completely as possible (the voluminous rubber phase contains much solution which can be removed by pressure), and the water is removed from the solution until the residue is of constant weight.

The Protein Complex

The above residue is a pale brown, somewhat hygroscopic syrup with a biscuit-like odour, which slowly crystallises in air in well-formed elongated plates of considerable size. It is almost

*With the exception of the very small amounts sometimes found with the organic-soluble constituents.

completely soluble in a small amount of cold water, and the solution gives the ninhydrin test for protein. Fehling's solution is however unaffected owing to the absence of free reducing sugars, while the reactions with ammoniacal silver nitrate and ammonium molybdate are masked by the fact that quebrachitol and the metallic phosphates are also not present as such, but as components of a chemical complex.

All four reagents however give normal positive tests if the aqueous solution of the complex is first hydrolysed by boiling it for half-an-hour with its own volume of 5N sulphuric acid. Phenylglucosazone (m.p. 203°) has been obtained by suitable treatment of the hydrolysate.

It may therefore be stated that the components of the complex include protein, phosphate, glucose or fructose (or polysaccharides from which they are derivable), and quebrachitol. The observations noted in the ensuing section indicate that this complex also comprises the remaining inorganic constituents which have been recorded by previous workers. It is anticipated that the material will readily lend itself to the determination of its major constituents.

The pure Rubber Hydrocarbon

The rubber remaining after the above water extraction is milled to the thinnest possible sheet in a stream of water, surface water is removed, and the product is then dried to constant weight *in vacuo* over sulphuric acid. This operation is usually complete in 48—72 hours, but on occasion the rubber at this stage is too tacky to be handled quantitatively.

This product consists of the rubber hydrocarbon in a highly purified state. It retains a relatively small amount of protein and when burnt yields only an imponderable residue which is phosphate-free. Other features of the substance including the above-mentioned variability will be discussed in a subsequent paper.

Typical Results

It will be noticed that the total amount of non-caoutchouc constituents (excluding water) is about 4 per cent of the latex and 10—15 per cent of the latex total solids. These figures are appreciably higher than have been observed hitherto, and are mainly attributable to the inclusion for the first time in a table of this kind of the "sulphur complex", which is seen to be a major non-caoutchouc constituent.

The percentage of water is obtained from the "Total Solids" determinations, which is a routine part of each analysis.

TABLE I

Latex Constituent	Latex A per cent	Latex B per cent	Latex C per cent
Ammonium Salt ...	0.02	0.03	0.02
Ester	0.06	0.06	0.02
Fatty Acid Complex ...	0.41	0.33	0.47
Sulphur Complex ...	0.92	0.94	1.16
Protein Complex ...	2.56	1.45	2.05
Caoutchouc	32.92	27.17	32.98
Water	62.75	69.78	63.68
Total	99.64	99.76	100.38

Additional Considerations

(i) In most cases the amount of a given constituent isolated by the above procedure, though definite, is admittedly small. For the more detailed investigations which are in progress, these small amounts are allowed to accumulate over a period, and are stored in solution in well-stoppered bottles which are kept in the dark.

(ii) It will be appreciated that, in dealing with a mixture of this degree of complexity which shows wide variations in composition from day to day, technical difficulties are encountered from time to time in applying the above method of analysis. All such difficulties to date have been readily dealt with by using ordinary measures, and particulars are therefore omitted from the above account.

(iii) Objection may be raised that the above method does not ensure that latex constituents of high volatility would be observed. This point has been met by subjecting the fresh latex from time to time to distillation with steam. On no occasion has any evidence thus been obtained of the existence in latex of detectable amounts of volatile acids, bases, or aldehydes such as hydrocyanic, hydrosulphuric, formic and butyric acids, ammonia, methylamine and acetaldehyde, claims for all of which have been put forward in the earlier literature.

Summary

(i) A method is described for the quantitative isolation of the chief constituents of Hevea latex *in the form in which they occur in nature*.

(ii) Several hitherto unknown constituents have been observed and receive a preliminary description. They include a sulphur-containing plastic material which is of major importance.

(iii) The known major constituents—sugar, quebrachitol, phosphates, protein, fatty acids—are shown to exist in fresh latex in the main as components of stable chemical complexes.

(iv) It is hoped in the near future to report the results (a) of more detailed investigations, and (b) of applications of the method in the study of some fundamental problems.

Acknowledgement

Grateful acknowledgement is made to Dr. E. Rhodes, Senior Officer of the Chemical Division for his active interest and encouragement throughout the course of the work.

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LATEX STRAINING MATERIALS

BY

J. D. Hastings and K. C. Sekar

In a previous number of this Journal (1) attention was called to the deleterious effects on raw rubber which arise from copper contamination, and emphasis was laid on the ease with which this contamination can occur when brass sieves are used for straining latex.

It is generally known to producers that traces of copper in raw rubber induce tackiness, but it is not, however, so generally realised that its presence in amounts which are considerably less than those required to produce tackiness will seriously affect its ageing properties and its plasticity; it is desirable to lay considerable emphasis on this point. In the experiments which are recorded here the amounts of copper present are much less than those required to give tackiness.

Latex strainers have been made of brass wire gauze since the early days of the plantation industry and time has shown that, when used on *well controlled* estates, copper contamination serious enough to disturb the manufacturer does not occur frequently. The possibilities of contamination by accident or misuse are, however, considerable and with the growth of the export market for preserved latex the possibility is very serious. Since other straining materials are now available it is of importance to examine their suitability for the purpose. This paper reports the results of laboratory investigations made with brass and other gauze materials which can be considered as alternatives for the straining of latex.

Alternative Straining Materials

Apart from certain types of cotton voile which can be considered, metal gauzes made of monel metal, stainless steel and nickel are available. If cotton voile could be used, all danger of metallic contamination would naturally be removed, but unfortunately it cannot be considered satisfactory for estate practice under ordinary conditions. It is rapidly clogged by fresh field latex and is extremely fragile, so that frequent changes and replacements are necessary, rendering its use laborious and expensive. For the straining of preserved (ammoniated) latex however, it can be used without so much difficulty. Clogging does not occur

so frequently and on account of the lowered viscosity a larger volume of latex can be strained without the frequent changes of sieves required with field latex. Voile strainers are in fact now used with success on one large estate in Malaya which is concerned only with the export of preserved latex, but undoubtedly a metallic gauze would be suitable provided it cause no metallic contamination.

Monel metal is an alloy of nickel and copper containing from 25 to 35 per cent of copper. For this reason it might, *a priori*, be considered to be of doubtful value but it is claimed that although it is stronger than nickel its properties are very similar to those of nickel.

Both nickel and stainless steel should not give copper contamination but it is necessary to ensure that these metals will not cause deleterious effects in the rubber. Experiments have been made to ascertain their effect on the discolouration of latex and their resistance to corrosion.

Copper Estimation

The detection and estimation of traces of copper in milk, food stuffs and allied substances is of paramount importance on account of its poisonous nature. In order to estimate minute quantities it is necessary to employ some method which is more sensitive than the usual methods of gravimetric analysis and the literature describing such determinations is considerable. The methods described are mostly colorimetric for which reagents such as dimethylglyoxime, potassium ferrocyanide, sodium diethylxanthate and sodium diethyl-dithio-carbamate are used. Several of these reagents for the estimation of copper in rubber and latex were tested but were found to present certain difficulties in manipulation. The sodium diethyl-dithio-carbamate test was finally adopted, and although it is not completely satisfactory, it was considered to be the best and most suitable for the work.

Description of Method used to estimate Copper

The determinations were carried out as follows:—
A weighed quantity of rubber of 10 to 20 gm. is ashed in a platinum basin. The ash is dissolved in 5 to 10 cc of dilute hydrochloric acid. The solution is then made alkaline with a few ccs of strong ammonia solution, to precipitate any iron present, and filtered. The filtrate and washings are acidified with dilute sulphuric acid and made up to 100 cc in a separating funnel. After cooling, 10 cc of 0.1 per cent solution of sodium diethyl-dithio-carbamate are added when a yellowish-brown colour develops if copper is present. A known volume of carbon tetrachloride, 20 or 25 cc, is then added

from a burette and the separating funnel well shaken. The brown colour is easily dissolved in the carbon tetrachloride layer leaving a clear solution above. The depth of colour is then compared in a colorimeter with that given by a known amount of copper, taken up in an equal volume of carbon tetrachloride, from a standard copper sulphate solution, acidified and treated with 10 cc of sodium diethyl-dithio-carbamate.

It is necessary to ash the rubber slowly in order to avoid ignition and loss by 'creeping'. With traces of copper of the order of 0.05 mgm. it was found that, unless the colour is dissolved in carbon tetrachloride, comparisons are difficult owing to lack of intensity of colour. Chloroform can be used in place of carbon tetrachloride but, owing to its low boiling point, rapid loss by evaporation during the colour comparisons is unavoidable under tropical conditions. Another alternative is amyl alcohol but, with this reagent, rapid fading occurs. Unless the solution is made acid the colour is not readily taken up in carbon tetrachloride. A slight fading is noted after a while but it is not sufficiently rapid to interfere with the determinations. All reagents must of course be tested for freedom from copper impurities.

Determinations of the amounts of copper present in solutions by the methods described gave good agreement with their known copper contents and indicated that the method was suitable for the work.

Effect of Nickel on the Copper Estimation

In certain experiments with nickel gauzes it was found that latex with which they had been in contact appeared to have a somewhat higher copper content than the controls. The reason was found to be that nickel itself affected the reaction, and its presence in traces gives a whitish yellow opalescence which intensifies the yellow copper colouration. Experiments were made with two further reagents—Rubeanic acid and 1.2 diamino-anthroquinon .3. sulphonic acid which are reported to be specific for copper in the presence of traces of other metals. Unfortunately, however, attempts to estimate copper in rubber with these reagents were not successful on account of the difficulties experienced in comparing the very faint colours developed under the conditions required for the test. It was therefore decided that the suitability of monel metal and nickel gauze for latex work should be judged on the assumption that the total copper content found by the dithio-carbamate test was due to copper and that the effect of nickel in rubber should be investigated.

Natural Copper Content of Latex

In all samples of rubber or latex examined during the experiments, copper was always found to be present even in those which were known to have been prepared with strict attention to the avoidance of contamination. Special samples of latex were therefore collected to avoid contamination. The trees were tapped with a metal knife but the first latex which flowed after tapping was rejected so as to ensure that no metallic contamination could have occurred in the latex collected. Non-metallic spouts were used and the latex was collected in a glass vessel. Copper was found in all samples. The following table (1) gives the copper contents found.

TABLE 1

Copper Contents of Sheet Rubber and Latex

Sample of Rubber and Source	Copper Content Mgm. per 100 Gm. of Rubber	Sample of Latex and Source	Copper Content Mgm. per 100 Gm. of Latex
R.R.I. Smoked Sheet	0.31	Estate D	0.32
Estate A „ „	0.25	R.R.I. Experiment Station	0.22
„ B „ „	0.16		
„ C „ „	0.18	Estate E	0.21
R.R.I. I. 290/1 Smoked Sheet	0.27	„ F	0.19

The results are in agreement with those of Shimada (2) who found copper to be present in all types of raw rubber. Samples of smoked sheet examined by him were found to contain approximately 0.31 mgm. of copper per 100 gm. of rubber. He suggests that, in view of the widespread distribution of copper in minute quantities in biological materials, it is most probable that the copper in the crude rubber is introduced from the original latex. This suggestion is in agreement with the conclusions to be drawn from the results above.

Effect of straining fresh Field Latex through Brass Sieves

To determine whether an increased copper content could be found after straining normal field latex through a 60 mesh brass wire gauze, samples were taken from the latex as soon as it was

brought to the factory by the tappers, and immediately after it had been strained. The copper contents found were 0.20 and 0.19 mgm. per 100 gm. of latex. The brass wire gauze was almost new, and in good condition. The latex was from an early collection and little or no incipient putrefaction had occurred. It appears therefore, that under these ideal conditions, the use of a brass sieve does not result in an appreciable increase in the copper content of the latex.

Experiments with other metallic straining Materials

Corrosion Trials

Samples of brass, monel metal, stainless steel and nickel gauzes of 60 mesh were immersed in ammonia solutions of various strengths for 24 hours. The loss in weight was then determined and the condition of the material noted. Results are given in Table II.

TABLE II

Corrosion Trials with different Gauzes in Ammonia Solutions

60 Mesh Gauze	Percentage Loss in Weight after Immersion for 24 hours in solutions of commercial Ammonia			Condition of Gauze after removal	Condition of Gauze after 14 days Immersion	Colour condition of 0.7 per cent Ammoniated Latex after storage for 6 weeks in contact with Gauzes
	2.8 per cent	1 per cent	0.5 per cent			
Brass	0.6-1.5	0.4-0.7	0.1-0.3	Corroded	Brittle and Corroded	Normal
Monel Metal	0.1	Nil	Nil	Unchanged	Unchanged	„
Stainless Steel	Nil	Nil	Nil	„	„	Slightly Discoloured
Nickel	0.1-0.3	0.1	0.07	„	„	Normal

The brass gauzes which were kept in contact with ammoniated latex for 6 weeks were in fair condition after removal, and serious corrosion was not evident. This is probably due to the protective action of a thin film of rubber which enables the gauze to resist further attack. In practice where continual passage of latex through the sieve occurs this protective action would not have taken place. Monel metal, stainless steel and nickel gauzes are satisfactory in their resistance to corrosion and, although the latex in which stainless steel gauze had been stored for 6 weeks was

slightly discoloured, it was not badly affected and it is certain that in practice no discolouration in preserved latex could be attributed to the use of stainless steel sieves.

In order to test the effect of corrosion due to the acids produced by incipient putrefaction in latex, samples of the gauzes were allowed to remain in contact with fresh latex and were examined after appreciable putrefaction had taken place. Except in the case of the brass gauze no loss in weight could be detected and the materials were not visibly affected.

Samples of monel metal and brass wire gauzes were immersed in a 0.5 per cent solution of ammonia and the amounts of copper dissolved after different periods of immersion were determined. The results indicated that copper was dissolved from the brass gauze immediately on contact with the ammonia and that in a very short while comparatively large quantities were present in solution. With monel metal, however, only a very small amount was taken up even after 60 days immersion. Table III gives the results of these tests.

TABLE III

Amounts of Copper dissolved from 1 square inch of Gauze immersed in 100 cc. of a 0.5 per cent Ammonia Solution for varying Times

Type of Gauze	1 Minute mgm.	2 Minutes mgm.	5 Minutes mgm.	1 Day mgm.	3 Days mgm.	60 Days mgm.
Brass	0.52	0.93	1.03	faint blue solution	blue solution	deep blue solution
Monel Metal	Nil	Nil	Nil	0.017	0.025	0.054

It had been observed that monel metal strainers which had been used for some months at the Institute for the straining of ammoniated latex had developed a blue sheen in places and many of the strands appeared to be copper-coloured. The appearance suggested that selective dissolution of the alloy was taking place and that the nickel was dissolving more rapidly than the copper. This was not unexpected from the results of the corrosion trials which had shewn the pure nickel gauzes to be more readily attacked by ammonia than the monel metal. Pieces were cut from one of these discoloured strainers and immersed in 0.5 per cent ammonia solution for 24 hours. Copper determinations shewed the amount dissolved was now greater than that previously found with new

material, and amounts of 0.064 to 0.084m. grm. were dissolved from 1 square inch to 100 cc of ammonia.

When copper determinations were made on latex which had been allowed to putrefy partially in contact with gauzes, higher contents were obtained from the latex in which the brass gauzes had been immersed. The results are given in Table IV.

TABLE IV

Copper present in 100 cc. Latex after contact with 1 square inch for 4 hours before Preservation

Type of Gauze	Copper present per 100 gm. of Latex mgm.
Control (No Metal)	0.19
Brass	0.32
Monel Metal	0.24
Stainless Steel	0.19
Nickel	0.25

Subsequent similar experiments gave rather higher copper contents in latex which had been in contact with the brass gauze than those shewn in Table IV. It is to be noted that the latices in which the monel metal and nickel gauzes were immersed give higher contents than either the control latex or that in which the stainless steel gauze had been kept. The reason for the higher figures in the case of the nickel gauze is probably due to interference by traces of nickel in the estimation.

Whilst it is true that the conditions under which the experiments were carried out are rather more drastic than those which usually occur in estate practice, in view of the fact that, under estate conditions, latex sometimes arrives at the factory in a semi-coagulated and partially putrefied condition, the conclusion must be drawn that it is possible for traces of copper to be introduced into latex by the use of brass sieves in the manufacture of smoked sheet or crepe rubber. This also applies to the use of monel metal sieves but to a much lesser degree, even when it is assumed that the increase in observed copper content is entirely due to the addition of copper and not to traces of nickel.

Vulcanising and Ageing Experiments

In view of the fact that it is possible for traces of copper and nickel to be introduced into latex from sieves of brass, monel metal and nickel, investigations were carried out on the physical

properties of rubber prepared from latex to which had been added amounts of copper, nickel and iron approximating to those which might be introduced by accident. It has been reported (3) that the presence of 0.00005 per cent of copper in raw rubber is sufficient to cause it to soften and become tacky on keeping. This figure is less than that now found to be normally present in all samples of raw rubber and latex. There is evidence to show that quantities in excess of 0.00005 per cent may be present without visible signs of softening or development of tackiness during storage for periods up to fifteen months.

Rubber containing added Copper

In connection with other experiments, sheet rubber was prepared early in 1935 from latex to which small quantities of copper sulphate had been added before coagulation. The coagulum was machined to standard sheet and dried in hot air at 120°-130°F. Vulcanisation tests shewed that when the samples were cured in a rubber-sulphur mix (100 : 10) at 149°C, the rate of cure was the same in all cases, and the tensile strengths of the vulcanisates were normal. On ageing in the oxygen bomb, however, the effect of added copper was evident.

Table V and Figure I show the results of these ageing experiments together with the copper contents of the sample. The figures for percentage of copper added, represent the copper added per 100 grammes of rubber in the latex. The values obtained by determinations on the rubber itself were lower for the obvious reason that some copper is lost in the serum during coagulation.

TABLE V

Effect of added Copper on Ageing Properties
Vulcanised Rings aged in Oxygen at 60°C and 300 lb./sq. inch Pressure

Sample No.	Copper added	Copper found in dry rubber	Time of cure to give 1.30 Kg./Sq. mm. at 890 per cent Elongation	Ageing Cure	Tensile strength after ageing for hours :— Kg./Sq. mm.			
	per cent	per cent	Mins.	Mins.	0	24	48	72
L 213	Nil	0.00018	98	80	1.24	1.24	0.84	0.07
L 213/1	0.0005	0.00057	101	80	1.17	1.26	0.81	0.09
.. /2	0.001	0.00074	101	80	1.11	1.12	0.11	0.07
.. /3	0.002	0.00133	101	80	1.07	0.97	0.08	0.05

FIGURE 1.

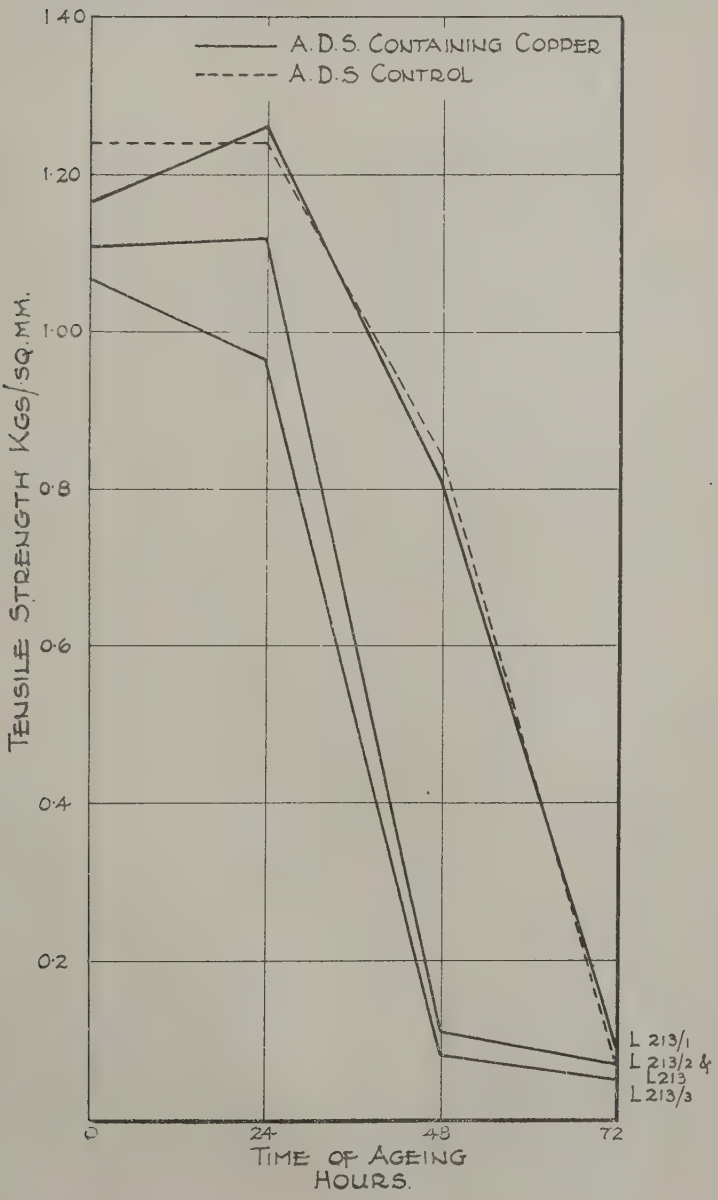
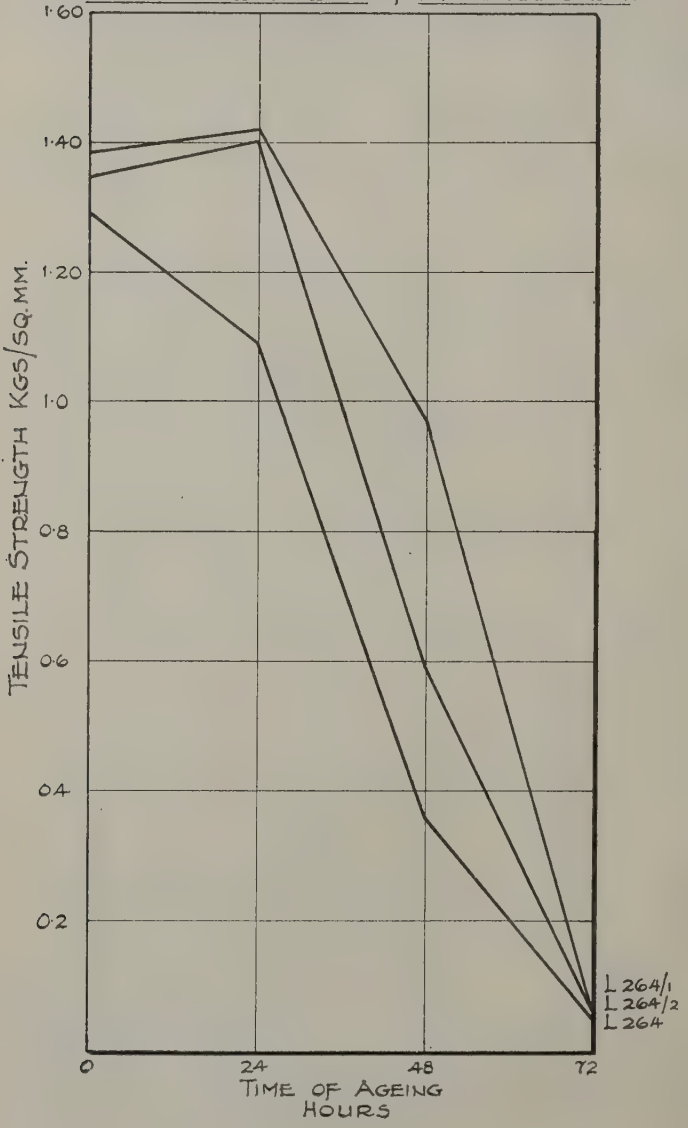

A.D.S. CONTAINING COPPER
A.D.S CONTROL
1·40
1·20
1·00
0·8
0·6
0·4
0·2
TENSILE STRENGTH KGS/SQ.MM.
0
24
48
72
TIME OF AGEING HOURS.
L 213/1
L 213/2 &
L213
L 213/3

FIGURE 2

EFFECT OF SMALL AMOUNTS OF NICKEL AND IRON ON THE AGEING OF AIR-DRIED-SHEET.



The ageing figures were obtained two months after the sheets had been prepared. Unfortunately sufficient rubber was not available for a series of ageing tests after long storage, but examination of that which remained showed no tackiness whatever after fifteen months. Samples L 213/2 and L 213/3 were however appreciably softer than L 213/1 which appeared normal and it is evident that both have deteriorated as they were 'short'.

Effect of Traces of Copper on Plasticity

In connection with investigations on the plasticity of raw rubber, experiments are in progress which show that traces of copper influence plasticity without appearing to affect the ageing properties. Slight differences in plasticity are evident immediately after preparation when ageing experiments do not indicate any differences in the rubber. Although the ageing properties of raw rubber derived from latex to which have been added amounts of copper of the order of 0.0005 per cent calculated on the weight of rubber present, do not appear to be altered even after storage for several months, the plasticity shows a slight progressive difference and the rubber tends to become softer. The work is incomplete but serves to confirm the statement made by Rhodes (5) that it is possible that variation in estate rubber is caused by the use of brass sieves.

Rubber containing added Iron and Nickel

Several workers have commented on the deleterious effect of iron salts on raw rubber. Eaton (4), many years ago reported that the effect of a comparatively large amount of iron was to cause softening and tackiness, and he stressed the necessity for cleanliness and freedom from corrosion in all instances where latex comes into contact with iron. Little information is available concerning the effect of traces of nickel on raw rubber since it is a contamination which is seldom likely to occur. Hot-air-dried sheet was prepared from latex to which nickel chloride and ferrous sulphate had been added prior to coagulation. The amounts added were larger than the amounts added in the case of copper, but were nevertheless not more than traces. The rate of cure of the rubber was unaffected. Further, the addition of traces of nickel or iron did not appear to affect the ageing properties. The quantity of nickel and iron added was based on the dry rubber content of the latex, and the percentages actually present in the rubber were considerably smaller. The results are given in Table VI and Figure II.

TABLE VI

Effect of added Nickel and Iron on Ageing Properties Vulcanised Rings in Oxygen at 60°C and 300 lbs./sq. inch Pressure

Sample No.	Metal added	Time of Cure to give 1.30 Kgs./Sq. mm. at 890 per cent Elongation	Ageing Cure	Tensile Strength at Break after Ageing for hours :— Kgs./Sq. mm.			
	per cent	Mins.	Mins.	0	24	48	72
I, 264		106	90	1.29	1.09	0.36	0.05
I, 264/1	0.023 Nickel	109	90	1.39	1.42	0.97	0.06
/2	0.020 Iron	109	90	1.35	1.40	0.59	0.06

Costs of alternative Sieving Materials

From information received from the makers of monel metal, stainless steel and nickel gauzes, the prices in local currency per square foot of material are as follows:—

Type of Wire Gauze	30 Mesh 31 W.G.	40 Mesh 34 W.G.	60 Mesh 37 W.G.	80 Mesh 37. W.G.
Monel Metal	$0.60	$0.61	$0.68	$0.86
Nickel	$0.68	$0.75	$0.86	$0.93
Stainless Steel	$2.57	$2.79	$3.76	$4.22

Monel metal has recently been imported into this country and is now available. The following quotations for monel metal and Staybrite stainless steel wire gauzes were supplied by a local firm.

	30 Mesh	40 Mesh	50 Mesh	60 Mesh	80 Mesh	100 Mesh
Monel Metal	$0.68	$0.72	$0.78	$0.80	$0.98	$1.08
Staybrite Stainless Steel	$1.88	$2.06	$2.28	$2.68	$3.20	$3.38

The cost of 60 mesh monel metal gauze is therefore nearly four times that of brass wire which is sold at 20 to 25 cents per square foot. It has however been reported that in actual estate practice the monel metal has a life of at least four times that of ordinary brass gauze. The extra costs involved in equipping strainers with monel metal or stainless steel are in any case a comparatively small item of general expenditure.

Conclusions

It has been shown that comparatively large amounts of copper are rapidly dissolved from brass gauze in dilute solutions of ammonia. Estates which are exporting preserved latex are advised to use ammonia in the field as an anticoagulant, and whilst they might not use brass sieves for straining the latex after ammoniation, there is serious risk of contamination arising if they are used for straining latex to which ammonia has already been added in the field. It has also been shown that latex can be contaminated with copper from brass sieves under certain circumstances when dealing with untreated field latex. *It is therefore strongly recommended that estates should cease to use brass sieves for the straining of latex of any kind.*

Stainless steel, nickel or monel metal strainers should, in the case of estates which do not prepare preserved latex, be substituted.

In the case of estates which prepare preserved latex, the fact that monel sieves become in time less resistant to attack by ammonia, makes the use of this metal inadvisable. Such estates should therefore use strainers made of stainless steel or nickel when handling the comparatively viscous field latex, and cotton or stainless steel for the less viscous fully ammoniated latex.

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27th May, 1936.

A SURVEY OF LATEX COAGULANTS USED BY MALAYAN SMALL-HOLDERS

BY

EDGAR RHODES

Introduction

Although it is the fact that rubber produced on small-holdings has for many years formed a large part of the total amount of rubber exported from Malaya, it has not until recently become possible to obtain reliable information as to the nature of the coagulants commonly used by small producers. A great part of the rubber from Malayan small-holdings finds its way to the United States of America and, although the fact of a steady demand might perhaps be taken as some indication that the intrinsic properties of such rubber are reasonably satisfactory and that dangerous coagulant substances are therefore not in general use, it was nevertheless considered necessary to take the first opportunity of making a survey of the coagulants commonly employed. Information based on direct analyses of reliable samples drawn from all parts of the country has been lacking and, in its absence, nobody could state with any certainty that the most suitable available coagulants were used either universally or even by the majority of small-holders. A survey of this nature demands for its prosecution an organisation which is able to make a close search through many villages in all districts, because most small-holders, or the tappers employed by them, purchase their supplies of coagulant in small bottles from local shops and there can be no certainty that the coagulants sold in one shop are identical with those sold in others nearby, or in neighbouring villages. The recent establishment of the Small-Holders' Advisory Service with Asiatic Rubber Instructors stationed in a number of districts made such a survey possible and towards the end of 1934 coagulants were collected in the States of Kedah, Perak, Negri Sembilan, Pahang, Selangor, Johore and also in Malacca Territory.

Method of Sampling

The Asiatic Rubber Instructors, who were responsible for the collection of samples, purchased unopened bottles of all available brands of coagulant from shopkeepers in all districts.

Their meetings with the small-holders also often enabled them to discover which brands if any were specially favoured in the district. The samples were forwarded to the Institute for analysis together with notes as to cost and, where possible, relative popularity.

Testing

Before analysis, the volume of each sample was measured so that, where analysis indicated that constituents were present in a diluted form, fairly accurate cost comparisons could be made against the price of the same material at commercial strength.

Each sample was analysed qualitatively and the amounts of major and minor constituents were determined. No attempt was made however to estimate the amounts of harmless impurities of which traces were found in some samples. Careful watch was kept for traces of the metals, copper and manganese, but in no case were they found present in dangerous amounts.

The results of the analyses of samples collected and tested between September 1934 and March 1936 are set out and discussed according to States.

TABLE I

Coagulants used by Small-holders in Kedah

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
1	Lion	Perak	Kulim	325	15	Sulphuric acid	...	56.4	...	...	...	...	14.12	...	...	Perak No. 5
2	Lark	do	do	350	15	Sulphuric acid	...	51.1	...	...	...	...	14.47	...	...	Perak No. 7
3	Axe	Penang	do	730	23	Sulphuric acid	...	64.3	...	...	...	...	8.45	...	...	Perak No. 2
			Alor Star	640	25								10.48			
4	Bow & Arrow	do	Bandar Bahru	330	8	Sulphuric acid	...	66.7	...	...	...	...	6.27	...	...	Perak No. 14
			Langgar	680	22			..					8.36			
5	Three Stars	Bagan Samak	Bandar Bahru	165	6	Sulphuric acid	...	65.2	...	...	...	...	9.62	...	...	Perak No. 10
6	Triple Fives	do	do	185	6	Sulphuric acid	...	55.3	...	...	...	...	10.12			

TABLE I—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
7	Flag & Lion	...	Kulim	300	15	Sulphuric acid	...	61.8	...	...	...	...	13.96			
8	Tiger	...	Bandar Bahru	180	6	Sulphuric acid	...	65.7	...	...	...	...	8.75	...	...	Perak No. 4
9	Colonial Coagulant	Penang	Alor Star	680	22	Sulphuric acid	Alum	22.2	...	...	...	11.8	25.14	...	...	Perak No. 19
10	Three Rubber Leaves	do	Bandar Bahru	680	28	Sulphuric acid	Hydrochloric acid	52.5	1.1	...	...	...	13.53	...	...	Perak No. 20
			Alor Star	680	25			,,	,,				12.08	...	...	Johore No. 17
11	Acid Geta	do	Bandar Bahru	690	25	Sulphuric acid	Hydrochloric acid	54.0	0.7	...	...	...	11.58	...	...	Perak No. 22
			Alor Star	640	25			,,	,,				12.48			

TABLE I—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
12	Acidotex	Penang	Bandar Bahru	335	12	Sulphuric acid	Hydrochloric acid	53.1	1.2	...	...	...	11.64	...	...	Perak No. 24
			Alor Star	630	25			,,	,,				12.89			
13	Arrow & Target	do	Bandar Bahru	330	11	Sulphuric acid	Hydrochloric acid	50.5	1.8	...	...	...	11.39			
14	Sun Latex	do	Alor Star	650	25	Sulphuric acid	Hydrochloric acid	53.5	1.5	...	...	...	12.40	...	...	Perak No. 21
15	Triple Twos	...	Bandar Bahru	175	5	Sulphuric acid	Acetic acid	48.6	...	4.2	...	...	10.14			
16	"90" Formic acid	Bagan Samak	do	335	15	Formic acid	Sulphuric acid	23.1	...	...	33.7					
17	Scale	...	Kulim	260	22	Formic acid	...	...	...	...	88.7	...	...	...	15.59	
				305	22						82.5	...	...	...	14.29	

TABLE I—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross-Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
18	Anchor & "S"	...	Kulim	630	50	Formic acid	...	...	...	...	79.1	...	...	...	16.40	
19	Umbrella	Penang	Alor Star	530	45	Formic acid	...	...	...	...	80.5	...	...	...	17.24	
20	Lion Globe	do	do	640	35	Formic acid	...	...	...	...	77.0	...	...	...	11.61	
21	...	do	do	610	45	Formic acid	...	...	...	...	91.2	...	...	...	13.22	
22	Horse	do	do	540	45	Formic acid	...	...	...	...	89.6	...	...	...	15.20	
23	Cat Glacial Acetic	...	Kulim	300	20	Acetic acid	...	...	...	94.7	...	...	...	12.66		
24	Flower Plant	...	Baling	300	23	Acetic acid	...	...	...	96.8	...	..	...	14.24		

TABLE I—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95%	Acetic acid 99%	Formic acid 90%	
25	British Acetic acid	Penang	Baling	315	22	Acetic acid	...	...	...	97.1	...	...	...	12.93		
26	Umbrella	do	Alor Star	610	35	Acetic acid	...	...	...	97.5	...	...	...	10.58		
							Average prices paid by users						11.89	12.60	14.79	
							Dealers costs for sulphuric, acetic and formic acids in four gallon lots are taken as						4.80	7.90 to 8.25	9.45 to 9.90	

Coagulants used by Small-Holders

(i) The State of Kedah

In addition to the coagulants detailed in Table I, a few small-holders were found to be employing alum as a coagulant and, in rarer cases, sodium bisulphite. The survey thus indicates that of the twenty-eight different brands of coagulant used in this State, sixteen contained sulphuric acid alone, or were mixtures in which it was either a major or a very appreciable constituent. In eight of these cases sulphuric acid was the only coagulant present; in five cases it appeared in admixture with small amounts of hydrochloric acid and in three other instances it was found in association with alum, acetic acid and formic acid respectively. The concentration of sulphuric acid varied approximately between 22 and 67 per cent from brand to brand. This is indicative of considerable dilution by the bottlers who are no doubt actuated firstly by considerations of profit, secondly by the possible loss of trade which might result from injuries by a 95 per cent commercial acid in the hands of unskilled persons, and thirdly by the desire to offer a product which, although cheaper to produce, will have approximately the same efficiency as formic or acetic of good quality.

Six samples were formic acid of good quality of which the strengths lay between 79 and 90 per cent. This acid is sold commercially in two strengths of 80 per cent and 90 per cent so that a charge of dilution by the bottler cannot here be made with fairness. Four samples were undiluted acetic acid of good quality.

TABLE II

Coagulants used by Small-holders in Perak

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95%	Acetic acid 99%	Formic acid 90%	
1	Flying Horse	Kuala Kangsar	Taiping	305	10	Sulphuric acid	....	49.9	...	...	...	...	11.34			
			Kuala Kangsar	320	9			,,	...	...	...	...	9.73			
2	Axe	Penang	do	355	11	Sulphuric acid	...	64.3	...	...	...	...	8.32	...	...	Kedah No. 3
				700	25			,,					9.58			
3	Aeroplane	Kampar Tapah	do	325	10	Sulphuric acid	...	57.3	...	...	...	...	9.23			
				325	9			57.3	...	...	...	...	8.22			
				285	7			59.5	...	...	...	...	7.13			
4	Tiger	Kampar	Taiping	325	10	Sulphuric acid	...	57.7	...	...	...	...	9.17	...	...	Kedah No. 8
			Kuala Kangsar	330	9			57.7	...	...	...	...	8.17			
			Tapah	295	7			66.1	...	...	...	...	6.20			

TABLE II—*(Continued)*

Sample No.	Brand if any	Where bottle	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95 % $	Acetic acid 99 % $	Formic acid 90 % $	
5	Lion	Taiping	Taiping	325	15	Sulphuric acid	...	56.4	...	...	...	...	14.14	...	...	Kedah No. 1
			Kuala Kangsar	330	9			,,					8 34			
6	Malay Rubber Coagulant	Penang	Larut	610	35	Sulphuric acid	...	63.4	...	...	...	...	15.62			
7	Lark	Taiping	do	285	10	Sulphuric acid	...	51.1	...	...	...	...	11.85	...	...	Kedah No. 2
8	Ubat Geta Para	Batu Kuran	do	340	9	Sulphuric acid	...	58.9	...	...	...	...	7.75			
9	Coagulam Axe	...	Selama	700	25	Sulphuric acid	...	67.2	...	...	...	...	9.17			

TABLE II—(*Continued*)

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
10	Three Stars	Bagan Samak	Selama	350	10	Sulphuric acid	...	69.0	...	...	...	...	7.15	...	...	Kedah No. 5
			South Krian	330	12			65.2	...	...	...	...	9.63			
11	Poh Aun	do	do	650	40	Sulphuric acid	...	66.5	...	...	...	...	15.98			
				710	40			55.8	...	...	...	...	17.44			
12	Aik Leong Co.	do	do	700	35	Sulphuric acid	...	66.7	...	...	...	...	12.94			
13	Elephant	Kuala Kangsar	Kuala Kangsar	330	9	Sulphuric acid	...	43.1	...	...	...	...	10.93			
			Tapah	275	7			59.6	...	...	...	...	7.37			
14	Bow & Arrow	Penang	Kuala Kangsar	745	28	Sulphuric acid	...	58.9	...	...	...	...	11.04	...	...	Kedah No. 4
15	Globe	...	do	640	19	Sulphuric acid	...	39.4	...	...	...	...	13.02			

TABLE II —*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents Major	Constituents Minor	Composition by weight per cent Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	What user pays to purchase in this form 4 gallons of Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	Cross Reference
16	Hen	...	Tapah	320	7	Sulphuric acid	...	52.5	...	...	...	...	7.23			
17	Double Cock	...	do	260	7	Sulphuric acid	...	52.9	...	...	...	...	8.77			
18	Ship	...	Bruas	315	9	Sulphuric acid	...	56.6	...	...	...	11.8	8.71			
19	Colonial Coagulant	Penang	Taiping	710	38	Sulphuric acid	Alum	22.2	...	...	...	...	41.63	...	...	Kedah
			South Krian	720	40								43.21			No. 9
20	Three Rubber	do	Taiping	710	38	Sulphuric acid	Hydrochloric acid	52.5	1.1	...	...	...	16.44	...	...	Kedah
	Leaves		Kuala Kangsar	670	35								17.19	...	...	No. 10 Johore No. 17
21	Sun Latex	do	Larut	350	10	Sulphuric acid	Hydrochloric acid	53.5	1.5	...	...	...	9.21	...	...	Kedah
			South Krian	330	10								9.78			No. 14

TABLE II—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
22	Acid Geta	...	South Krian	710	40	Sulphuric acid	Hydrochloric acid	54.0	0.7	...	...	...	18.01	...	...	Kedah No. 11
23	Coagulatex	...	do	710	40	Sulphuric acid	Hydrochloric acid	52.5	1.1	...	...	...	18.52			
24	Acidotex	...	do	680	45	Sulphuric acid	Hydrochloric acid	53.1	1.2	...	...	...	21.52	...	...	Kedah No. 12
25	Shield & Basket	Penang	Kuala Kangsar	710	26	Sulphuric acid	Hydrochloric acid	54.0	0.7	...	...	...	11.71			
26	Acetic Acid 99%	...	Selama	710	48	Formic acid	Sulphuric acid	17.9	...	...	61.5	...	...	...	17.98	
			South Krian	654	45			,,			,,		...	...	18.30	
27	90% Formic	...	Selama	320	18	Acetic acid	Sulphuric acid	23.9	...	51.7	...	...	...	19.58		
28	Balance	...	Trong	285	25	Formic acid	...	...	...	...	88.6	...	...	...	16.18	

TABLE II—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc.	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
29	Shamrock	...	Taiping	635	50	Formic acid	...	...	...	...	90.5	...	...	...	14.31	
30	Acetic Acid	...	Kuala Kangsar	230	25	Formic acid	...	...	...	...	80.0	...	...	...	22.22	
31	Formic Acid	...	do	275	23	Formic acid	...	...	...	...	90.2	...	...	...	15.17	
32	Formic Acid	...	Kati	345	24	Formic acid	...	...	...	...	74.9	...	...	...	15.19	
33	Formic Acid	...	Padang Rengas	255	20	Formic acid	...	...	...	...	88.1	...	...	...	14.56	
34	Formic Acid	...	Kuala Kangsar	230	25	Formic acid	...	...	...	...	89.0	...	...	...	19.97	
35	Chinese Label	...	Selama	250	20	Formic acid	...	...	...	...	90.6	...	...	...	14.54	

TABLE II—*(Continued)*

Sample No.	Brand if any	Where bottle	Districts where sold	Volume per bottle cc	Price per bottle cent	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95 % $	Acetic acid 99 % $	Formic acid 90 % $	
36	Hh. Man	...	Selama	295	22	Formic acid	...	...	...	...	70.7	...	...	...	17.26	
37	Md. Rani	...	do	385	20	Formic acid	...	...	...	...	88.3	...	...	...	9.60	
38	Ah Min	...	do	310	20	Formic acid	...	...	...	...	82.4	...	...	...	12.51	
39	...	...	do	205	20	Formic acid	...	...	...	...	57.4	...	...	...	27.80	
40	...	...	do	210	20	Formic acid	...	...	...	...	55.8	...	...	...	27.92	
41	...	...	do	220	20	Formic acid	...	...	...	...	60.4	...	...	...	24.62	
42	...	...	do	225	20	Formic acid	...	...	...	...	59.6	...	...	...	24.40	

TABLE II—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc.	Price per bottle cents	Constituents		Composition by weight per cent					What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Alum	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
43	Cock Brand	...	Enggor	315	26	Formic acid	...	...	...	...	88.7		...	...	15.23	
44	'Japanese acid	...	Kuala Kangsar	210	15	Formic acid	...	...	...	...	77.5	...	...	...	15.08	
						Average prices paid by users							11.29*		18.04	Note* Excluding No. 19
						Dealers costs for sulphuric, acetic and formic acids in four gallon lots are taken for comparison as							4.80	7.90 to 8.25	9.45 to 9.90	

(ii) The State of Perak

Table II indicates that the situation in Perak is very similar to that which maintains in Kedah. Of forty-four samples analysed, no fewer than twenty-seven consisted either of sulphuric acid alone or contained it as a very appreciable constituent. Mixtures of sulphuric acid with one or other of the substances alum, hydrochloric acid, acetic and formic acid were again found. The concentration of sulphuric acid from brand to brand varied over the range 22-69 per cent which is similar to that found for preparations used in Kedah. Many of the brands used in Kedah are also found in Perak and emanate from the same group of wholesale bottlers. Of the seventeen samples of formic acid found in this State, eight were in use in the single district of Selama. Six of the samples of formic acid were seriously below commercial strength and had obviously been diluted deliberately by the bottler. No samples were found in which acetic acid was the sole coagulant present.

Reports from the various districts indicated that the more popular brands were those which were later found to consist either solely or mainly of sulphuric acid.

(iii) The State of Negri Sembilan

The investigations made in this State indicated beyond doubt that the coagulant in almost exclusive use is formic acid of good quality and strength. One sample, although labelled "acetic acid", was found to consist of 88.2 per cent formic acid. The survey revealed only one sample consisting of any coagulant other than formic acid. This sample was "Aeroplane Brand" coagulant (see Perak No. 3) containing 57 per cent of sulphuric acid. In this State however, this brand of coagulant was not found to be popular, and the conclusion can safely be drawn that formic acid is the coagulant in general use.

TABLE III

Coagulants used by Small-holders in Pahang

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent		What user pays to purchase in this form 4 gallons of		Cross Reference
						Major	Minor	Formic acid	Acetic acid	Formic acid 90% $	Acetic acid 99% $	
1	Acetic acid	Kuala Lipis	Kuala Lipis	660	50	Formic acid	...	85.4	...	14.51		
2	Best Acetic acid	do	do	290	25	Formic acid	...	85.3	...	16.54		
3	...	do	do	280	25	Formic acid	...	79.7	...	18.32		
4	...	do	do	270	25	Formic acid	...	84.3	...	17.97		
5	...	do	do	285	25	Formic acid	...	85.7	...	16.74		
6	Monsoon	Bentong	Bentong	345	25	Formic acid	...	85.5	...	13.87		
		Raub	Raub	350	25			89.6	...	13.04		
		Temerloh	Temerloh	345	30			89.1	...	15.97		

TABLE III—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent		What user pays to purchase in this form 4 gallons of		Cross Reference
						Major	Minor	Formic acid	Acetic acid	Formic acid 90% $	Acetic acid 99% $	
7	...	Dong	Dong	300	28	Formic acid	...	89.4	...	17.08		
8	...	do	do	275	25	Formic acid	...	90.0	...	16.52		
9	Tiger	Bentong	Bentong	345	25	Formic acid	...	83.5	...	14.19		
		Temerloh	Temerloh	385	30			90.1	...	14.16		
10	No. 800	do	do	330	30	Formic acid	...	70.5	...	21.09		
11	...	do	do	325	25	Formic acid	...	65.0	...	19.36		
12	Cat	Bentong	Bentong	310	26	Formic acid	...	81.3	...	16.87		
		Pekan	Pekan	360	25			84.3	...	13.48		
13	Formic acid No. 1872	Bentong	Bentong	700	55	Formic acid	...	67.4	...	19.07		
14	Shamrock	Raub	Raub	340	25	Formic acid	...	89.9	...	13.38		
		Temerloh	Temerloh	345	30			89.9	...	15.81		
		Beserah	Beserah	340	30			79.1	...	18.24		
		Gambang	Gambang	630	54			82.4	...	17.02		
		do	do	670	60			87.8	...	16.68		
		Pekan	Pekan	340	30			83.6	...	17.26		

TABLE III—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent		What user pays to purchase in this form 4 gallons of		Cross Reference
						Major	Minor	Formic acid	Acetic acid	Formic acid 90% $	Acetic acid 99% $	
15	Chinese Label	Kuantan	Kuantan	730	55	Formic acid	...	88.7	...	13.90		
16	...	do	do	700	55	Formic acid	...	88.6	...	14.51		
17	Crossed Flags	do	do	660	55	Formic acid	...	88.7	...	15.37		
18	Cock	do	do	720	55	Formic acid	...	83.8	...	14.91		
19	Ant Formic	Pekan	Pekan	365	30	Formic acid	...	83.5	...	16.11		
20	Japanese Acetic	do	do	325	25	Formic acid	...	59.4	...	21.17		
21	Tiger Acetic	do	do	345	23	Acetic acid	...	...	97.9	...	12.26	
22	...	do	do	325	25	Acetic acid	...	...	96.3	...	14.37	

TABLE III—*(Continued)*

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent		What user pays to purchase in this form 4 gallons of		Cross Reference
						Major	Minor	Formic acid	Acetic acid	Formic acid 90% $	Acetic acid 99% $	
23	Cat Formic	Pekan	Pekan	365	25	Acetic acid	...	...	96.7	...	12.75	
24	...	do	do	340	25	Acetic acid	...	...	97.8	...	13.53	
25	...	do	do	320	25	Acetic acid	...	...	93.6	...	15.02	
						Average prices paid by users				16.31	13.59	
						Dealers costs for formic and acetic acids in four gallon lots are taken as :—				9.45 to 9.90	7.90 to 8.25	

(iv) The State of Pahang

It will be seen from Table III that, in this State, formic and acetic acids are used exclusively. Of twenty five samples, twenty were found to consist of formic and five of acetic acid. In four instances formic acid was being sold in a diluted condition but, in all other cases, the coagulant, whether formic or acetic acid, was of reasonably good commercial strength.

(v) The State of Selangor

The search in this State revealed the fact that formic and acetic acids are used almost exclusively. In all, five samples consisting of sulphuric acid were found and these represented in each case the remains of consignments which had proved to be virtually unsaleable in the various districts. Of these, four were brands which find a ready sale in the north but the Selangor small-holders are not apparently converted to their use. In the remaining instance, a 34.5 per cent sulphuric acid was being offered as acetic acid but it was not popular. It is a fairly common practice in some parts of this State for the head-man of a village to purchase a whole demijohn of commercial formic acid and to issue it in small lots to the small-holders. It may be said of this State that undesirable coagulants are not in use.

TABLE IV

Coagulants used by Small-holders in Johore

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent				What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
1	Sun	Muar	Muar	670	45	Formic acid	...	...	...	...	70.1	...	...	15.68	
2	Red Demijohn	do	do	630	40	Formic acid	...	...	...	...	65.3	...	...	15.91	
				315	21	Formic acid	...	...	...	...	58.4	...	...	18.67	
3	Chinese Label	...	do	640	46	Formic acid	...	...	...	...	84.9	...	...	13.84	
4	Lion	Muar	do	680	40	Formic acid	...	...	...	...	73.0	...	...	13.18	
5	Bee	...	Johore Bahru & Kota Tinggi	650	45	Formic acid	...	...	...	...	84.7	...	...	13.37	
6	Shamrock	...	do	650	45	Formic acid	...	...	...	...	94.2	...	...	12.01	

TABLE IV—(*Continued*)

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent				What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
7	Cock's Head	...	Johore Bahru & Kota Tinggi	660	45	Formic acid	...	...	..	...	92.9	...	...	12.00	
8	Soroban	...	do	550	34	Formic acid	...	...	...	...	79.1	...	...	12.78	
9	Cat's Head	...	do	300	25	Formic acid	...	...	...	...	80.9	...	...	16.85	
10	Cat Brand	...	Kluang	...	...	Formic acid	...	...	...	...	84.8				

TABLE IV—(*Continued*)

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent				What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Sulphuric acid 95% #	Acetic acid 99% #	Formic acid 90% #	
11	800 Brand	...	Kluang	...	...	Formic acid	...	...	...	...	90.8				
12	Spider	...	do	...	...	Formic acid	...	...	...	...	85.5				
13	Green Demi-john	...	Muar	670	33	Formic acid	Sulphuric acid	19.5	...	...	38.7				
14	Elephant	...	Kluang	..	...	Formic acid	Sulphuric acid	25.4		...	35.0				
15	Swan	...	Johore Bahru & Kota Tinggi	620	35	Sulphuric acid	...	66.4	...	...	...	14.68			
16	Motor Car		do		...	Sulphuric acid	...	68.2							

TABLE IV—(*Continued*)

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent				What user pays to purchase in this form 4 gallons of			Cross Reference
						Major	Minor	Sulphuric acid	Hydrochloric acid	Acetic acid	Formic acid	Sulphuric acid 95% $	Acetic acid 99% $	Formic acid 90% $	
17	Three Rubber Leaves	Penang	Johore Bahru & Kota Tinggi	700	40	Sulphuric acid	Hydrochloric acid	52.5	1.1	...	...	18.79	...	...	Kedah No. 10 Perak No. 20
18	Red Demijohn	...	Muar	680	35	Acetic acid	...	...	...	66.5	...	...	13.93		
19	Acetic acid	...	do	750	35	Acetic acid	...	...	...	92.9	..	...	9.04		
						Average prices paid by users						16.74	11.49	14.48	
						Dealers costs for formic acid in four gallon lots is taken for comparison as						...	...	9.45 to 9.90	

TABLE V

Coagulants used by Small-holders in Malacca

Sample No.	Brand if any	Where bottled	Districts where sold	Volume per bottle cc	Price per bottle cents	Constituents		Composition by weight per cent		What user pays to purchase in this form 4 gallons of		Cross Reference
						Major	Minor	Formic acid	Acetic acid	Formic acid 90% $	Acetic acid 99% $	
1	...	...	Alor Gajah	700	40	Formic acid	...	46.2	...	20.23		
2	...	...	do	690	40	Formic acid	...	64.2	...	14.78		
3	...	...	Rumbia	630	48	Formic acid	...	83.2	...	14.98		
4	...	...	Durian Tunggal	630	45	Acetic acid	...	...	99.5	...	12.91	
						Average prices paid by users				16.66		
						Dealers costs for formic and acetic acids in four gallon lots are taken as :—				9.45 to 9.90	7.90 to 8.25	

(vi) The State of Johore

It should be mentioned that, in addition to the coagulants detailed in Table IV, a number of small-holders were noted to be employing self-made mixtures of alum with acid. It will be observed that, in this State, formic and acetic acids are not used exclusively and it was noted in North Johore that the Green Demijohn Brand was one of the two brands most popular with small-holders. This coagulant contains a by no means negligible proportion of sulphuric acid. Four other brands of coagulant containing this acid either alone or in appreciable proportions were finding a sale in various districts and, in view of these facts, it would appear that in this State the amount of rubber produced by the use of sulphuric acid cannot be taken as negligible.

(vii) Malacca Territory

In this territory formic and acetic acids are seen to be in exclusive use, but in two cases formic acid was being sold in a diluted condition.

Cost of Coagulants

From the volume, price and percentage composition of the samples, comparable figures have been derived in Tables I to V for the prices paid by users, for four gallons of commercially pure coagulant when purchased in bottles. It will be seen from the tables that, for the same brand of coagulant, users in different districts pay in some cases widely different prices. This had been expected; different retailers work to different margins of profit. A very rough indication of prevailing prices for different coagulants is obtained by averaging all the calculated prices found for a particular coagulant in different States.

The average values are given in Table VI.

TABLE VI

Coagulants	Estimated price paid by dealer for 4-gallon lots	Average price paid by user for 4 gallons when purchased in bottles			
		Kedah	Perak	Pahang	Johore
	$	$	$	$	$
Formic Acid	9.45 – 9.90	14.79	18.04	16.31	14.43
Acetic Acid	7.90 – 8.25	12.60	...	13.59	...
Sulphuric Acid	4.80	11.89	11.29	...	...

It is at once seen that, between the purchase of acid in demijohns by the dealer and its sale in bottles, there is a very large increase in price and that, where small-holders can either individually or collectively purchase supplies in four gallon lots, not only do they obtain a coagulant of known and constant strength but they also effect a considerable saving in cost. It is found however that, in many districts, small-holders are not easily persuaded to the system of collective purchase, and they or their tappers are likely to continue to obtain their individual supplies in bottles. Because of this fact and because the difference between "demijohn prices" and "bottle prices" is considerable, it was felt that there might be scope for large importers of formic acid to bottle and distribute supplies of good-quality acid, in sealed bottles at more reasonable prices. Enquiry revealed that this would in all probability prove impracticable. A large organisation considered the matter carefully and it was estimated that when bottled, sealed, labelled and packed for distribution, in free cases containing 36 bottles the price per half-pint bottle of formic acid would approximate 25 cents, which is equivalent to a price of $16 for four gallons of the acid and shows no improvement on the prevailing prices shown in Table VI. This is unfortunate because if a good-quality bottled formic acid of guaranteed strength could have been placed on the market at a competitive price it would have assisted materially the efforts which are being made to wean the small producer from the use of undesirable but cheaper coagulants. The small shopkeeper-bottler, whose overhead charges are small, can make a handsome profit on the bottling and local distribution of formic and acetic acids but there is little scope for the wholesale distribution of bottled supplies from a central business depot to distant sale points.

The position is further complicated by the fact that sulphuric acid, because of its very much lower initial cost and higher coagulative efficiency, does admit of this procedure. Certain non-European organisations have undoubtedly made use of the fact and are distributing by road, bottled and labelled sulphuric acid coagulants from central depôts to shopkeepers in many districts at prices lower than those of acetic and formic acids. The small-holder or more particularly the tapper, who is often paid by the holder on the weight of sheet rubber which he produces, is concerned mainly as to the price of available coagulants. He has usually no knowledge of their chemical nature and a brand of coagulant which produces more rubber at a lower cost is attractive to him. It is unfortunate that these non-European organisations have taken advantage of the low price of sulphuric acid in this way; they have popularised to an appreciable extent coagulant

mixtures about the use of which the manufacturer is nervous and it will take time and much propaganda to displace them.

Labelling of bottles

In nearly all cases, the samples consisting essentially of sulphuric acid were being sold in bottles bearing coloured distinctive labels designed to attract the eye. In most cases the label gave no indication of the chemical nature of the contents. In no single case, where sulphuric acid was the sole or main constituent, was the fact disclosed on the label. In a few cases, samples containing this acid as an active constituent bore labels which mis-represented the nature of the contents. In Kedah (see Table I, No. 16), a mixture of sulphuric and formic acids was on sale as "90" Formic acid. In Perak, (see Table II, Nos. 26 and 27) two mixtures, one of sulphuric and formic acids and the other of sulphuric and acetic acids were sold as "Acetic acid 99%" and "90% Formic" respectively; in Selangor, a sample of sulphuric acid was sold under the label "Acetic acid B". This indicates that those who bottle sulphuric acid for sale to small-holders are by no means anxious to advertise the fact but rather to hide it.

Among the samples which were found to consist of formic and acetic acids, there were again a few cases of mis-description. In Pahang (see Table III, Nos. 1, 2, 20 and 23) three samples of formic acid were described as "Acetic acid", "Best acetic acid" and "Japanese acid" respectively and one sample of acetic acid was sold as "cat formic"; in Negri Sembilan one sample labelled "acetic acid" was found to consist of formic acid.

There is at present no legal obligation on the bottler of coagulants to describe on the label the nature and strength of the active principle, and those bottlers whose coagulants are sold under brand names only and who do not attempt to disclose the chemical nature of the materials used, commit no breach of the law; those on the other hand who sell say sulphuric acid in the guise of acetic acid, could probably be punished by law for such mis-description. They are however in a minority. It would greatly assist the efforts of the officers of the Small-Holders Advisory Service, if all those who bottle or sell coagulants were bound by law to describe on the labels the nature and strength of the coagulant concerned. Asiatic Rubber Instructors could then in the course of their duties advise small-holders to avoid certain specific brands of which the constituents were admittedly undesirable. Analysis of samples collected from time to time would make it possible to punish those who mis-described deliberately the nature of the coagulant sold.

Individual Coagulants and the Extent of their Use

In order to obtain an indication of the extent to which the various coagulants are in use, the acreages of rubber on estates of less than 100 acres, as shown by the Rubber Statistics Handbook 1935, are set out by States in Table VII against the coagulants favoured.

TABLE VII

Coagulants favoured	Acreage of rubber on estates of less than 100 acres							Total
	Kedah	Perak	Selangor	Negri Sembilan	Pahang	Malacca	Johore	
Acetic and formic acids	...	...	157,850	82,707	76,902	74,985	...	392,444
Mainly sulphuric acid	100,691	254,886	...	...	...	...	...	355,577
Mainly acetic and formic, but sulphuric acid also used in appreciable amounts	...	...	...	...	...	..	392,589	392,589

It would seem that on roughly one-third of the total acreage of small-holdings, the coagulants used are those employed by European-owned estates. In the four territories, Selangor, Negri Sembilan, Pahang and Malacca which make up this acreage, the position with regard to coagulants is very satisfactory.

In one-third of the total acreage, the favoured coagulant is sulphuric acid. This acid is sold in a number of forms. It is found in the main as a simple mixture of sulphuric acid and water. It also occurs under different names in admixture with small amounts of hydrochloric acid. The composition of these brands is 53—54 per cent sulphuric acid, together with amounts of hydrochloric acid up to 1.5 per cent (see Table I, Nos. 10 to 14, Table II, Nos. 20 to 25 and Table IV, No. 17). Curiously enough one of these mixtures is named "Coagulatex" and in 1918 Eaton, Grantham and Day (1) described tests on a proprietary coagulant which bore this name and had an almost identical composition. It is probable that this preparation may have survived since that time. Sulphuric acid also appears in preparations which contain in addition, acetic or formic acids. These mixtures, like those containing sulphuric and hydrochloric acids, are designed to simulate pure acetic and formic

acids in pungency, appearance and effectiveness while allowing greater profit to the bottler. It is surprising that sulphuric acid is in such common use over such a large area and the indications are that it has been in common use for some years. This is the outstanding feature of the survey. Although nobody has been aware of the fact, users have undoubtedly consumed thousands of tons of rubber prepared by the use of this acid during the last few years. There have been many signs of nervousness on the part of manufacturers when, during slump times, some large estates proposed to use this acid and a few actually did so. Tests carried out by manufacturers' organisations on specially prepared samples led to the issue of a strong request by the Institute that estates should refrain from the use of this acid; it was further requested that any estate which did employ it should declare the fact to the buyer at the time of consignment. The feeling among manufacturers is one of timidity towards this coagulant, even when it is known to be in the hands of comparatively skilled persons. That it should now transpire that it has been largely used for some time by the country's most unskilled producers is disturbing. It is tempting to infer that, because of the undoubtedly large amounts of sulphuric acid-rubber which have been consumed without serious outcry, the grounds for the prejudice against its use are not strong but manufacturers may however have had difficulties which have not been made known and which may perhaps be traceable to the coagulant. Further there can be no gainsaying the fact that the use of numerous coagulants of this type must militate against uniformity in Malayan rubber as a whole and it would therefore be extremely unwise not to deter small-holders from their use wherever possible. Fortunately, the Small-Holders' Advisory Service of the Institute, which has brought the facts to light, can be and is being employed actively to advise and persuade small-holders in the territories concerned to use formic and acetic acids only. There are already indications that the propaganda is having the desired effect.

Although, in the remaining one-third of the total acreage of small-holdings, the chief coagulants are formic and acetic acids, the popularity in some districts of Johore of certain brands which contain sulphuric acid, is rather disturbing.

In all districts, where organic acids are in use, formic acid is much more popular than acetic acid. It will be observed from Tables I to V that, of seventy samples of these acids found in the country, fifty eight were of formic acid. On European estates formic acid has very largely displaced acetic acid and the same is apparently true of small-holdings.

Alum enjoys only a minor popularity as a coagulant.

Summary

A survey has been made of the coagulants employed by Malayan small-holders. Although in the main they are found to be employing formic and acetic acids, sulphuric acid is found to be employed to a much greater extent than has been supposed. Propaganda against the use of this coagulant was commenced recently through the Small-Holders Advisory Service, and reports from the districts are encouraging.

Acknowledgement

Thanks are due to Mr. K. C. Sekar, B.A., who was responsible for the analysis of coagulant mixtures, and to the Asiatic Rubber Instructors in all districts for the collection of the samples.

Literature cited

B. J. Eaton, J. Grantham and F. W. F. Day. *"The Preparation and Vulcanisation of Plantation Para Rubber"* Department of Agriculture, F.M.S., *Bulletin No. 27, April, 1918.*

9th April, 1936.

INTERNAL PROTECTIVE COATINGS FOR LATEX CONTAINERS

In an article in the previous issue of the Journal, (Volume 6 No. 2,) reference was made to a latex-zinc oxide mixture as a protective filming medium against discolouration of preserved latex. It was pointed out that this filming medium is very effective against discolouration, but that it possesses the disadvantage of reducing the stability of the latex. Producers were accordingly warned not to employ the medium except after consultation with the user.

Producers are now informed that new drums treated internally before assembly with a bituminous preparation approved by the Institute have recently become available in Malaya. The filming preparation used in these drums does not have the effect of reducing the stability of the latex and it is also effective against discolouration.

The preparation is not suitable for application to second-hand drums.

All necessary details are available to interested estates on application to the Institute.

E. R.

18th April, 1936.

NOTE

ON

PRELIMINARY RESULTS FROM THE STUDY OF SEEDLING TREES DERIVED FROM PROVED CLONES

BY

C. E. T. Mann

During the period 1928 to 1931 experimental work on breeding of Hevea was carried out by Mr. L. E. Morris, formerly Geneticist, in the Botanical Division. Hand pollinations were made between a number of different clones established on Pilmoor Estate, Batu Tiga. The clones used have been studied and tapped under the supervision of the Botanical Division from January 1928 and this work is still in progress.

As a result of the first season's work with hand pollination some 200 seedlings of known parentage were obtained and these were planted in April—June 1929 on the R.R.I. Experiment Station, (Experimental Block 4. A.)

TABLE I

Yields of Seedlings derived from proved Clones

Family	No. of Trees	Yield in pounds dry rubber per tree per year Age 5½ to 6½ years
A44 x B58	11	6.8
A44 x D61	30	7.9
A44 x B16	27	7.4
B84 x A44	8	8.0
D61 x A44	43	7.7
B16 x A44	7	7.5
A44 Illegitimate seedlings	125	5.9
B58 „	64	4.6
B84 „	14	5.7
D61 „	22	4.2
B16 „	3	2.7
Ordinary, estate seedlings	29	1.8

Interplanted with these legitimate crosses were seedlings of illegitimate origin from the various clones used in making the crosses and other seedlings from ordinary estate seed. After preliminary periods of test-tapping in 1933 and 1934 regular tapping was commenced in January 1935. All trees having a girth of 20 inches at 20 inches from ground level were tapped alternate-daily on half circumference with a single left to right cut at a slope of 20 degrees. The seedling material at present under investigation includes crosses made between the best of the Pilmoor clones and illegitimate seedlings grown from identified seeds of the various clones collected from the original buddings on Pilmoor Estate. The illegitimate seedlings may have been produced by cross pollination with buddings of other good clones with buddings of inferior clones, or with ordinary seedling trees surrounding the small experimental area in which the original buddings have been established. The yields obtained during the first tapping year from the most promising families of crosses and illegitimate seedlings from the various clones are tabulated below.

TABLE II

Comparison of Yields of Seedlings (Legitimate Crosses) Seedlings (Illegitimate) and Buddings of the Parent Clones

Family	No. of trees	Yield of dry rubber in pounds per tree per year. Age 5½ to 6½ years
A8 x A44 Crosses	5	6.2
A44 Illegitimate	125	5.9
A8 „	37	3.9
A44 x B58 Crosses	11	6.8
A44 Illegitimate	125	5.9
B58 „	64	4.6
A44 x D61 Crosses	30	7.9
A44 Illegitimate	125	5.9
D61 „	22	4.2
A44 x B16 Crosses	25	7.4
A44 Illegitimate	125	5.9
B16 „	3	2.7
B84 x A44 Crosses	8	8.0
A44 Illegitimate	125	5.9
B84 „	14	5.7
Buddings of the Parent Clones		
A44	54	6.6
B58	34	7.3
D61	14	6.9
B16	38	9.7
B84	17	7.4

The early results indicate that the legitimate crosses are on the whole high yielding trees. At the same time, the illegitimate seedlings of Clones A44 and B84 also give very promising yields. It will be noted that A44 is one of the parents in all the "pedigree" families. The particular value of clone A44 as a parent is also illustrated by the results tabulated in the second table. In addition, the yield records of buddings of the several parent clones at comparable age are also recorded for comparison with the records of the new seedling families.

The results tabulated indicate that:—

(*a*) The actual yields obtained from "pedigree" seedlings produced by careful hand pollination between high-yielding parent clones are approximately equal to the yields of budded trees of the same parent clones during the first tapping year.

(*b*) Pilmoor Clone A44 appears to be a very valuable parent for the production of high-yielding seedling families Clone B84 may also prove to be equally valuable but further families in which this clone has been used as a parent must be investigated to establish this with certainty.

(*c*) The yields of illegitimate seedlings of all the clones used are inferior to the yields of buddings at comparable age.

(*d*) Although A44 is the lowest yielding of the five principal clones used in this breeding work its seedlings are among the highest yielding groups studied. The high yields of the illegitimate seedlings of Clone A44 are particularly noteworthy.

It is necessary to sound a note of warning regarding the value of Clone A44 as a parent. The previous history of the clone indicates that the budded trees of A44 reach a high yield level at a very early age and thereafter the rate of increase in yield is slow. It will be necessary, therefore, to study the behaviour of seedlings derived from A44 for a number of years in order to ascertain whether the precocity shown by the buddings is inherited by the seedlings derived from this clone.

20th May, 1936.

A NOTE ON
THE MIXING OF FERTILISERS

BY

C. G. Akhurst

When fertilisers are applied on estates, it is sometimes desirable to use separate chemicals instead of complete chemical fertilisers, such as the "Enpekay" or the "Supram" Series, to supply the individual plant foods. Thus, ammonium sulphate supplies nitrogen; potassium sulphate supplies potash; while phosphates are supplied by superphosphate, basic slag or rock phosphate.

Where two or more such chemicals are being applied, it is advisable to mix them before applying, as mixing can be carried out for the small cost of $1/- per ton, and an economy of labour in applying the fertilisers is thereby effected.

Whilst some fertilisers can be quite safely mixed with others, it is undesirable to mix ammonium sulphate (or other ammoniacal fertilisers) with materials containing free lime. In the latter category, as is well known, is included the phosphatic fertiliser basic slag, while certain rock phosphates may contain a little free lime or calcium carbonate. On this account the following tests have been carried out by the Soils Division, with brands of rock phosphate which are in common use in Malaya.

Experimental Details

Three types of rock phosphate were used, viz.,

	P_2O_5 (per cent)
Christmas Island	36—38
Gafsa	27
Cheribon	28—30

Equal amounts (500 gms.) of each of these materials and of ammonium sulphate were thoroughly mixed by hand and stored in small canvas bags in the laboratory.

The nitrogen content was determined at intervals over three weeks. The samples removed were dissolved in water, and portions of the solution were used for analysis.

Results

Immediately mixing was completed an odour of ammonia was detected from both the Gafsa and the Cheribon phosphate mixtures, but not from the Christmas Island mixture, thereby indicat-

ing that interaction between the components in the mixture with either of the two first named phosphates was proceeding, resulting in a loss of nitrogen.

The analytical results are given below, together with the percentage loss of nitrogen from the mixtures (initially all three mixtures had the same percentage of nitrogen, *i.e.* 10.5 per cent).

	Nitrogen (per cent)				Loss of Nitrogen (per cent)		
	At Mixing	After 6 days	After 13 days	After 22 days	After 6 days	After 13 days	After 22 days
1. Christmas Island	10.5	10.5	10.2	9.4	...	2.9	10.5
2. Gafsa	10.5	9.7	8.8	8.8	7.6	16.2	16.2
3. Cheribon	10.5	9.1	8.7	8.7	13.3	17.2	17.2

It is apparent from these figures that appreciable losses of nitrogen (as ammonia) can occur from the mixtures, so that the desirability of mixing rock phosphates with sulphate of ammonia must be reconsidered in the light of the results shown above.

Both Gafsa and Cheribon Rock Phosphate must be deemed unsuitable for mixing with ammonium sulphate. The loss of ammonia is due to the occurrence of free lime or calcium carbonate in these rocks, either of which decomposes the ammonium sulphate.

Christmas Island Phosphate can be mixed with ammonium sulphate with little loss of nitrogen, since normally the mixture will be applied within a week after mixing, when rains will dissolve the ammonium sulphate and allow the soil clay to absorb the ammonium radical before interaction with the rock phosphate can take place.

Where Cheribon or Gafsa Phosphates are being used with ammonium sulphate, a separate application of the latter must be made one week previous to the application of the phosphate.

7th May, 1936.

PLANTING HOLES AND THE BREEDING OF MOSQUITOES

The customary procedure in preparing land for replanting (or planting from jungle, etc.) is to dig the planting holes in advance so that weathering of the soil on the sides of the holes can proceed before planting and filling is done.

A certain value to the soil accrues from this procedure, and although the advantages are not overwhelming, it is desirable to maintain the procedure.

On certain types of soil in the country especially on bare eroded areas, which are to be replanted, percolation of water below the top few inches is often difficult, and where planting holes are dug in such soil, water may remain standing for a considerable period during wet weather. Since the holes may be dug as long in advance of planting as six months, there is every possibility that mosquitoes will breed in any water which collects in the holes.

Hence, where replanting is being done *within half a mile* of sites of bungalows or lines, it is recommended that the holes be filled immediately with a mixture of top soil and green vegetable material. The green plant material can be rubber leaves, small twigs and any cover plants which are available.

The holes will require to be watched and, if water does collect, further filling should be done.

Such a filling will be porous, will permit a certain amount of weathering to take place in the soil in the hole, and will effectively prevent mosquitoes from breeding.

C. G. A.

Kuala Lumpur,

6th May, 1936.

LATEX IN INDUSTRY

R. T. Noble, Phd. The Rubber Age (New York) 384pp. 76 illustrations G.$7

REVIEW

This book has already been made the subject of very favourable comment in numerous journals dealing with rubber and latex. In spite of the comparatively recent publication of three very valuable works on latex and its applications, Dr. Noble's book has been welcomed as filling the need for a detailed description of the various known processes to which latex is being applied. That it does so there can be no doubt. The author approaches the various branches of the subject in a manner which at once denotes the fact of first-hand experience of a great number of the processes which he describes. It is this practical experience which has enabled him to introduce into the work, details which are not to be found in any of the other recent publications and which will make the book especially attractive not only to the student of latex technology but also to the practising technologist. The very full lists of references both to published research work and relevant patents which appear at the end of each chapter leave the reader in no doubt that the existing literature has been well surveyed. It is unfortunate however, as has been observed by another reviewer, that text references are not included, because this would have increased enormously the value of the book to the student.

Of the ten chapters which comprise Part I of the book, three deal with the preservation, shipment and properties of latex and methods of concentration. Two chapters are devoted to latex compounding, one to the coagulation of latex compositions and another to the vulcanisation of latex articles. Vulcanised latex, artificial latices and the examination of latex are also described.

Of the subject matter of Part I of the book, few criticisms can be made, but there are one or two very minor points which are worthy of note. On page 42 it is stated that quebrachitol may be prepared from completely dried serum by dissolving the quebrachitol in alcohol. Quebrachitol is not in fact soluble in alcohol though extremely soluble in water. It cannot, therefore, in fact be prepared from dried serum by extraction with alcohol.

On pages 39, 40, 136 and 186 references are made to the viscosity of latex and it is indicated that the viscosity of commercial ammoniated latex is approximately that of water. The viscosity

of latex containing 38 per cent solids is given as 1.5—2.0 centipoises at 20°C, and that of latex containing 60 per cent solids as 5—6 centipoises. These values are not in line with those of other workers. De Vries (1923) working with latex containing less than 38 per cent solids obtained relative viscosity values of 4—5.5; Blow (1929) obtained relative viscosities of 4—8.9 for latices containing 33—44 per cent solids; Madge (1935) gives values of 5—6 centipoises for 38 per cent and 40—43 centipoises for 60 per cent latex. Unpublished results recently obtained at the Institute in viscosity determinations with the Höppler viscometer on many samples of normal ammoniated latex and 60 per cent centrifugal concentrate are in good general agreement with those of Madge and other authors mentioned above. Although the bibliography to the chapter on the properties of latex includes the papers by the workers mentioned above, sufficient prominence to their findings does not appear to have been given in the text.

On page 174, in dealing with the Rubber Research Institute method of determination of dry rubber content, the author has described a technique which has been obsolete for some years. As early as 1932 the Institute published details of a better technique which is to all intents and purposes identical with that which the author himself uses. This is probably the only case in which the author has by accident included material which is not up-to-date.

Part II of the book consists of 14 chapters and deals entirely with the various latex processes which are in present-day operation. Impregnation, spreading, dipping, moulding, electrodeposition, artificial leather, latex thread, friction elements, adhesives and carpet manufacture are all fully described. Suitable mixes and hints on procedure are to be found in nearly all cases and this part of the book cannot fail to be of great value to practising technologists, as well as to those who seek guidance in respect of newly contemplated applications. Those whose interests are more general will find all the subject matter very readable and in this respect the book should commend itself to Malayan producers. Those who ship latex and who are interested in its future will find this book extremely interesting as well as instructive. No discerning producer-reader can fail to draw the conclusion that no matter what care he now bestows on preparation, he should strive so far as he is able to make it still more acceptable to the user. In the production of this book Dr. Noble has done the industry a great service.

E. R.

1st May, 1936.

PLANTING HOLES AND THE BREEDING OF MOSQUITOES

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C. G. A.

Kuala Lumpur,

6th May, 1936.